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Burns Bog Ecosystem Review

Report of the Special Advisor to the Minister of the Environment

Gregory J. McDade, Q.C.

March 31, 2000

Executive Summary of the Burns Bog Ecosystem Review Synthesis Report

Olive-sided flycatcher

Contents

Executive Summary 2

1. Introduction 4

2. Special Nature of A Raised Bog Ecosystem 8

3. The Studies at Burns Bog 10

4. Discussion 22

5. Threats to Burns Bog 26

6. Public Comments ... 28

7. Some Management Implications 29

8. Recommendations .. 33

9. The Way Ahead 34

Appendix 1 – Public Comments 36

Burns Bog is a raised bog ecosystem covering approximately 3,000 ha of the Fraser River delta between the south arm of the Fraser River and Boundary Bay. On June 1, 1999, the Government of British Columbia and Delta Fraser Properties Partnership – the owners of 2,200 ha of land within the Bog - agreed to undertake an ecosystem review to gain a full understanding of what is needed to preserve the ecological integrity of Burns Bog. The purpose of the Burns Bog Ecosystem Review (the Review) was to determine the factors crucial to preserving Burns Bog as a viable ecosystem, such as the hydrology, geology, flora and fauna. The BC Environmental Assessment Office (EAO) was charged with managing the review process.

The public and stakeholders contributed to developing the nature and scope of the studies undertaken. Gregory McDade, Q.C., Advisor to the Minister of Environment, Lands and Parks, facilitated public involvement throughout the review process. The public participated in reviewing study progress, and in Technical Review Meetings involving local, regional and international scientific experts. All project materials were accessible through the EAO Project Registry, at local information outlets, and over the Internet. The key Review findings and conclusions were developed from the results of technical studies, written submissions, Technical Review Meetings, and additional information and models developed by the EAO.

The data and models available were generally adequate to lead to conclusions concerning the requirements for the ecological viability of Burns Bog. However, the data and analyses used in the Review were limited by the short duration of the study, a lack of previous investigations, and limited comparative data and examples.

Burns Bog is globally unique on the basis of its chemistry, form, flora and large size. The Bog exhibits the typical characteristics of a raised bog ecosystem, including a peat mound above the regional water table, an internal water mound, acidic nutrient-poor water derived directly from precipitation, a two-layered peat deposit, and widespread peatland communities dominated by *Sphagnum* and members of the Heather family.

Today, the Bog is largely isolated from other natural areas by agricultural, residential and industrial development. Forty percent of the original bog area has been alienated by development. Many activities, especially peat mining, have disturbed the hydrology and ecosystems of more than half of the remaining bog area and these disturbances continue to affect the Bog today. Despite these disturbances, Burns Bog retains important ecological processes and continues to support distinct biotic communities. The destruction of vegetation and the upper porous acrotelm layer, combined with the alteration of the hydrological and soil regimes, have impeded the peat-formation process.

The Bog's hydrology is shaped by the water mound, fluctuating water levels in the acrotelm zone (top 50 cm), and an extensive system of ditches. The Bog's ecological viability is directly dependent on the extent and integrity of the water mound and the peat that encloses it. The upper porous acrotelm layer is vital to the persistence of the water mound and peat-forming communities dominated by *Sphagnum* mosses. Only 29% of the Bog's original acrotelm and its dynamic water storage zone remain intact. Water from the east side of Highway 91 may play an important role in sustaining shallow pools that support the main water mound.

The acrotelm plays a vital role in regulating and storing water. As a result of increased rapid discharge through ditches, the average position of the water table in the acrotelm is about 25 cm lower than it was in the 1930s. Many ditches reach to the centre of the water mound from all directions and threaten the future of the Bog. None of the natural drainage channels and little of the essential lagg zone at the margins remain in the Bog. Further disruption of the water mound poses high risk to the viability of Burns Bog. The existing area of acrotelm must be maintained and a fully functional acrotelm must re-develop over the area of the water mound.

A fully functioning lagg is required at the margins of the water mound. The lagg receives normal discharge from the bog and buffers bog water from adjacent mineral water. The overall loss of water storage and associated decline in the water table in the past few decades have contributed to the advance of forested vegetation adjacent to the lagg zone.

The Bog's water balance suggests a surplus of about 200 mm of precipitation over evapotranspiration for an average year. Monthly water balance analysis for an average year shows that there is a moisture deficit from April to September. The relatively low late summer water table, in the range of 27-39 cm below the surface, may explain why Burns Bog is located near the climatic limits for raised bogs on the west coast of North America.

Typical bog water occurs in much of the main part of the Bog. It has low pH and relatively low calcium concentrations. A relatively narrow zone of transitional water, confined to the peat mass, separates bog water from surrounding mineral-rich waters. Non-bog water with moderate pH and relatively high mineral concentrations occurs outside the zone of transitional water and appears to be constrained outside the peat mass. Typical bog ecosystems are associated primarily with true bog water, and associated, in part, with transitional water.

Originally, the Bog was covered in open heath and *Sphagnum* vegetation with scattered scrub pines. Today seven forest, nine shrubby and herbaceous, and six sparsely vegetated ecosystems occur. The unforested phases of the Lodgepole pine–*Sphagnum* ecosystem are likely responsible for most of the peat formation. Herbaceous ecosystems occur widely on abandoned peat workings and in some natural areas. Lodgepole pine and birch forests encircle the peat-forming central zone. Other forests, mostly dominated by western redcedar, occur mainly east of Highway 91. These forests include scattered old-growth trees and are considered to be regionally rare. Hardhack communities occur in the lagg zone at the Bog margins under influence of mineral-rich groundwater. The undisturbed peat-forming plant communities of the southern third and the north-west sector of the Bog are vital to its survival.

Various plant species, including cloudberry, bog-rosemary, crowberry and velvet-leaf blueberry, occur at the limits of their geographic range and are recognized as genetically and ecologically important. The Bog also supports at least 12 species of *Sphagnum*, which constitutes 86% of the regional *Sphagnum* flora.

The Burns Bog area includes several nationally and provincially listed animals in both the core central area and at the periphery. The Bog harbours the only known population of the red-listed Southern Red-backed Vole in the province, as well as the red-listed Pacific Water Shrew. It provides critical habitat for the regional Greater Sandhill Crane population. Rare dragonflies and water boatmen occur in the distinct wet habitats of the Bog. Areas at the Bog's periphery are especially important to rare species and wildlife diversity. The Bog plays an important regional role in ecological and wildlife diversity by providing habitat for Fraser River estuary waterfowl, and maintaining the largest extent of bog ecosystems in the Fraser Lowland.

The Bog area is highly sensitive to fire because only about 540 ha of fully functional peat-forming vegetation may survive the next 100 years under the current fire regime. The Bog is also at risk to a series of drought years that could markedly lower the position of the late summer water table and threaten typical bog communities. The Bog area must remain large to withstand these disturbances. Connectivity is limited, but is required to maintain wildlife corridors and the long-term viability of the Bog.

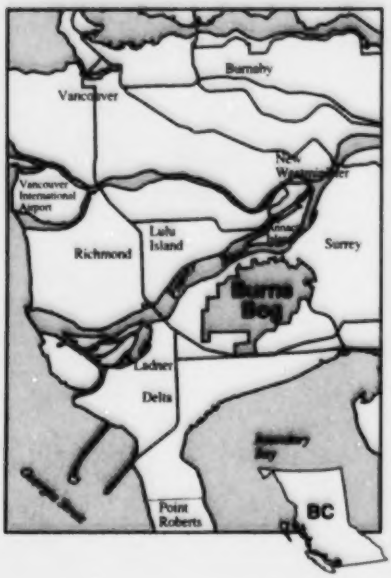
The conditions for recovery of Burns Bog ecosystems are favourable because there are many patches of bog vegetation in the disturbed area and a large natural zone surrounding the disturbed core. Widespread *Sphagnum* regeneration is occurring in the abandoned peat workings of the central bog.

To ensure the Bog's ecological integrity and viability, the entire extant water mound and most of the lagg zone are required. This requirement includes all of the west and central portions of the Bog. The area east of Highway 91 and north of 72nd Avenue is required to support high biodiversity attributes, to provide water to the main part of the Bog west of Highway 91, and to connect the Bog to upland habitats. The main water mound zone needs to be connected to the area east of Highway 91 via a broad zone of *Sphagnum* regeneration and typical bog water. Water in the shallow ponds within this zone supports the water mound. To sustain the water mound and peat-forming vegetation, ditches that drain the core of the Bog must be blocked as soon as possible or the Bog will not survive.

In summary, the area required to preserve Burns Bog as a viable ecosystem includes about 2,450 ha of the remaining bog. Approximately 360 ha, mostly in the south-east and north-east portions of the study area, have significant values that support the Bog, but that are not required to ensure ecological viability. Only 14 ha are of low or no value to ecological integrity. Further studies of hydrology and wildlife are required to define the ecological configuration of specific sites at the margins of the area required for viability. A program of ongoing monitoring of key indicators of ecological integrity should be established to ensure the viability of this globally unique ecosystem.

PART 1. INTRODUCTION

The Burns Bog Ecosystem Review (the Review) was established by the Minister of Environment, Lands and Parks in response to a great public upwelling of support for the bog and concern over the effects that development would have. The Terms of Reference directed us to undertake a very significant set of scientific studies, to determine the factors crucial to preserving Burns Bog as a viable ecosystem, and thereby help the public and government to define what might be required to ensure its ecological integrity is protected.



The report that is hereby submitted concurrently by the Environmental Assessment Office (EAO) delivers a clear and comprehensive answer to that question. Dr. Richard Hebda – a bog specialist and botanist from the Royal British Columbia Museum – led the Review as expert technical advisor to the EAO. After eight months of study, an exhaustive literature review, numerous consultants' reports, extensive public input into design and analysis of outcomes, advice and finally, peer review from international scientific experts, the study identifies an area of 2450 ha of public and private land that is required for a combination of hydrological, plant, wildlife and conservation biology needs.

My task was to ensure public participation, to liase with environmental and other citizen groups, and with the landowners, to ensure a fair and comprehensive process, and to advise the Minister on the ecological and practical implications that would arise from the scientific outcomes. In that regard, I am now pleased to recommend substantial acceptance of Dr. Hebda's conclusions, and to advise on the implications arising therefrom.

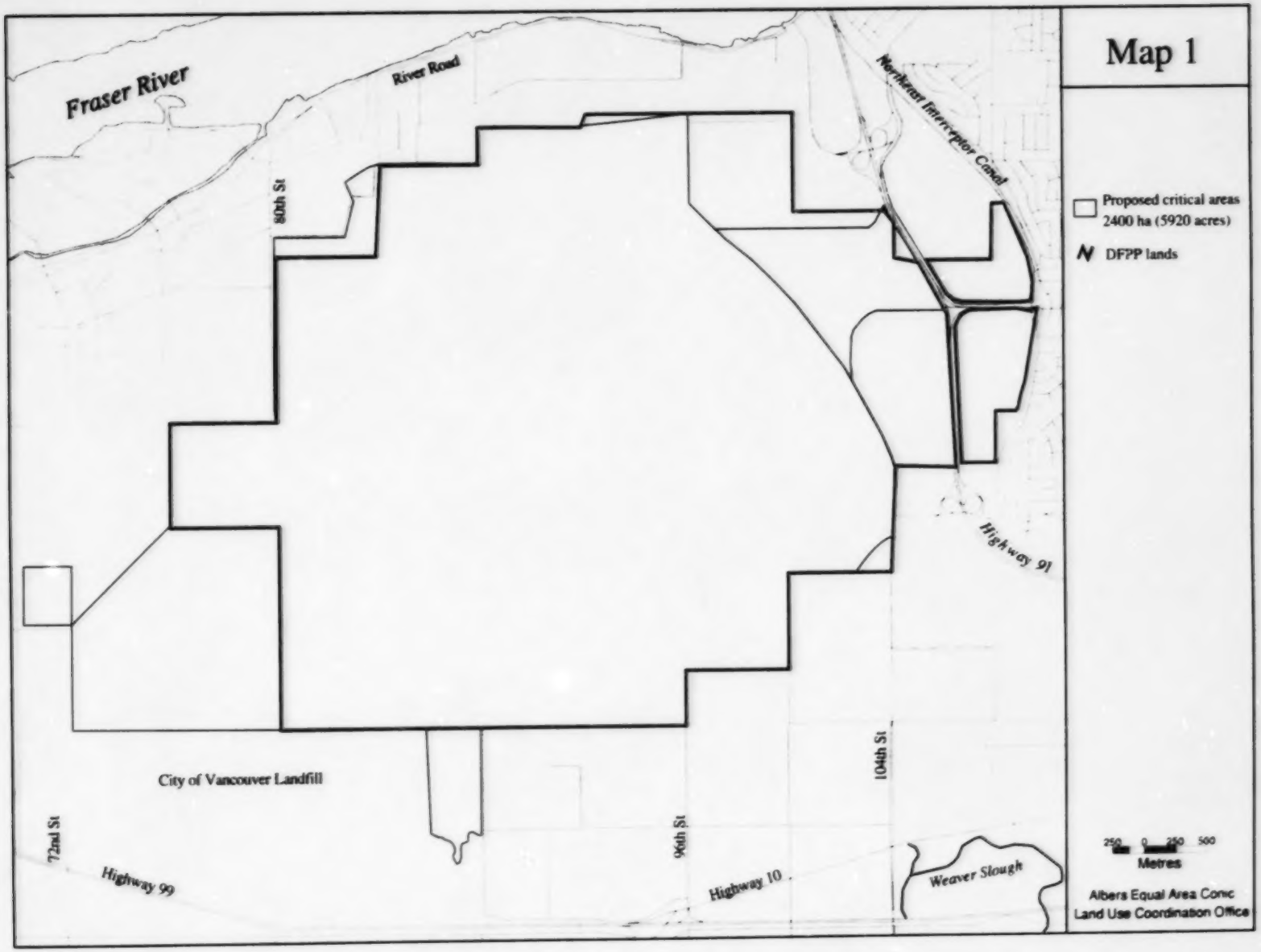
My conclusion, based upon both public response and the ecological needs described within the Ecosystem Review Report, is that Burns Bog deserves to be protected. It is an area of global, national, provincial and regional significance, justifying the participation of all levels of government. I recommend that these governments move with dispatch to ensure that virtually all of the recommended area (5920 acres, 2400 ha)[1] determined by Dr. Hebda becomes a protected area, and that a large majority of it be managed as a specially-protected ecological zone. This proposed area is shown on Map 1.

Such a project will not be easy. Approximately 5000 acres of the identified areas are currently owned privately, and by one owner. These will involve difficult choices for all levels of government in respect of public funds. Nevertheless, it is essential that these lands be managed in the public interest as a protected area if at all possible.

The outcome of such a public effort will be extraordinary. Not only is Burns Bog an ecological treasure, and one deserving of global and national recognition, but we are presented with a chance to protect a contiguous, almost road-less area of 5920 acres in the midst of a major metropolitan area. This would create a protected area more than five times the size of Stanley Park. Such an opportunity arises once in a lifetime, and is perhaps unique within the major cities of the world.

Although, legally speaking, decisions about development and zoning of the private lands here are the responsibility of the Corporation of Delta, it is my view that the primary responsibility and any fiscal burden for protection of Burns Bog should be shared by all levels of government. Extensive public interest from throughout the Lower Mainland as well as the number of species which can be considered endangered on at least a regional basis invites participation by the Greater Vancouver Regional District (GVRD). In fact, I recommend that,

[1] There are two small parcels on the southeast and southwest corners totaling 50 ha, which are owned by private agricultural interests and which have not been included in my recommended total, but were identified by Dr. Hebda in his total. These lands could be considered in later disucssions



Map 1. Proposed area of provincial protected status

Note To the Reader

This report is intended to be read in conjunction with the report of the Burns Bog Ecosystem Review prepared by Dr. Richard Hebda and the Environmental Assessment Office. Although I have participated fully in the process, reviewed all of the consultants and other reports, and had patient lessons by Dr. Hebda, my report must be understood to reflect only my comments and interpretations. The Synthesis Report should be considered the more scientifically authoritative. My comments have been designed to simplify, and to be read by a wider audience, and I apologize to Dr. Hebda and his team for any inaccuracy or loss of meaning that may result.

I want to commend Dr. Richard Hebda for his extraordinary dedication to this project and to scientific accuracy and honesty; and to express my admiration for the depth of his understanding of and affinity for Burns Bog. The Province of B.C., and all who care about Burns Bog, owe him a great debt of gratitude. I also want to acknowledge the hard work and integrity of the team at the Environmental Assessment Office, and in particular the project leaders, Alan Calder, David Johns and Daphne Stancil, as well as their Deputy Minister Dr. Sheila Wynn.

should Burns Bog be ultimately protected as park, it be owned or managed by the GVRD. However, the global, national and provincial significance of Burns Bog primarily dictates that the senior levels of government should take a prominent role in finding a way to preserve this special area. It would not be fair to leave these difficult decisions to the local government alone.

There are small areas of private land within the study area that were not found by the Ecosystem Review to be required for sustainability. These small areas of the private landowners' land, in four separate parcels, total approximately 537 acres, roughly 9.5% of Delta Fraser Properties' lands. The study does not attempt to determine whether these parcels should be developed or not. The study finds that these parcels have ecological value, but that their value is not so essential to be of provincial significance. These lands have real wildlife and other ecological values, and would be desirable additions to the protected area if the owner is willing to sell, and local government is able to acquire them. Otherwise, the question of development or rezoning of these lands should appropriately be left to the owner and the Corporation of Delta.

The Ecosystem Review Report leaves no doubt that Burns Bog is a special place. Burns Bog contains a raised domed bog ecosystem that is at the southern limits where such ecosystems are possible. A raised bog such as this one is rare and globally significant. Its size makes it unique in southern Canada and in western North America.

Domed or 'raised' bogs are not like regular bogs, of which Canada has a great deal. A domed bog operates in ways unique from any other ecosystem; it depends entirely upon rainwater, its interaction with the surrounding ecosystem is outward. In the following Part 2, I discuss in simple terms the unique nature of a domed bog ecosystem, and the implications for this Review.

This report attempts to summarize in Parts 3 and 4 some of the more significant findings of the Ecosystem Review Report, and to explain in layperson's terms the process of reasoning that led to these findings and which affect my recommendations and inform government's actions on this area.

The consultants' reports prepared for the Ecosystem Review catalogue a wide variety of species of plant and animal life. These reports identify 41 species of mammals, 9 amphibians, 175 birds, and 257 plant, 94 macrofungi and 26 lichen species. It is also clear that, because of the limited time for study in the Ecosystem Review, it is also highly likely that these reports present only a partial list.

Given the unique way in which a domed bog functions, it is no surprise that several of the species of wildlife catalogued in the report are either provincially or regionally endangered. One of the mammals, the Southern Red-backed Vole was thought to be extinct in B.C. Similarly, many of the plants are also red- or blue-listed. The Ecosystem Review establishes that Burns Bog is not about endangered species, or endangered plants; it is most appropriate to view Burns Bog in terms of a rare and endangered ecosystem.

In Part 5, I summarize the key threats facing the Burns Bog ecosystem.

In Part 6 and Appendix 1, I have tried to summarize and comment upon the substantial and varied public comments and public views that were brought before me, to the EAO, and to the Minister in this process.

Although it is not part of my Terms of Reference, this process has also taught me much about the sensitivity of the bog, and about the public views of it, and I thought it appropriate, in Part 7, to comment upon some management considerations that may arise out of the recommendations.

My recommendations are set out in Part 8.

The Ecosystem Review constituted a substantial study. There are few Canadian bogs that have been more thoroughly reviewed. We have learned much about its ecology and sustainability that was not known at the time of past announcements on potential developments for Burns Bog. The provincial government is to be commended for undertaking this review, and the landowner deserves great credit for co-operating in it. Ideally, all land use decisions would have this level of scrutiny; in a real world governed by economic constraints, this will rarely be possible.

Of course, we must recognize that even with this level of study, there is much that we cannot know. No area this size, no ecosystem or group of ecosystems this complex, can been fully mapped or fully catalogued, let alone understood, by scientific study over a single season of field work in a single year. Further, even the Ecosystem Review considered a great deal of literature on past studies, and from studies of other bogs around the world, we must recognize the inadequacies in our knowledge base of the bog's ecology. There is still much to learn. Section 6.6 of the Ecosystem Review sets out in more detail the Gaps and Limitations to be expected in these circumstances.

Many members of the public urged upon us that because of this level of uncertainty, we should adopt the precautionary principle, and urged us to make no decisions until extensive further study. Unfortunately, in this instance, this land is private land, with a significant financial value, and the bulk of it is currently zoned I-3 – Industrial Extraction. The owners have a legal right to undertake activities such as cranberry farming or sand extraction. Further, the province does not have a normal permitting or decision-making responsibility in this area (as it would in land use decisions involving Crown land). The land use decisions here are solely the power of the municipality, but arise only upon a re-zoning application. In other words, we do not have the luxury of postponing decision; if the critical portions of Burns Bog are to be protected now, the government must act soon. A decision today must be based on the best available information and knowledge.

Further, given the comprehensive analysis by Dr. Hebda and other scientists in the Ecosystem Review suggesting that the Bog is currently suffering a decline as a result of drainage and other activities on the Bog, it would not be responsible to wait for the results of further scientific study. We must find a way now to protect those areas that we know to be threatened.

The Ecosystem Review Process

The fundamental structure of the Burns Bog ecosystem review was determined by a public consultation process to develop the study framework and set the terms of reference. This was achieved through public working sessions and submissions.

A focussed research strategy was used to provide the information needed to guide future land management decisions in Burns Bog. Baseline mapping and technical studies were initiated to characterize the Bog communities and habitats. Studies were undertaken in the areas of geology, native soils, soil and water contamination, hydrology, water chemistry, plants and plant communities, wildlife and fisheries. A Geographic Information System approach was used to integrate the results of the technical studies and to focus on the needs of key species and critical processes associated with the Bog ecosystem. The goal of this analytical approach was to identify elements and processes essential to maintain the ecological integrity and long-term viability of Burns Bog.

Technical review meetings provided a mechanism to review the draft findings of the technical studies and to identify gaps and weaknesses in the analysis and synthesis of the data. At each technical review meeting, consultants presented their findings, followed by panel and public discussions to consider the implications of the results and discuss key issues. These meetings were facilitated by the Environmental Assessment Office and attended by consultants, technical experts in specific fields and the public. This review process provided a dynamic opportunity to discuss the full range of disturbed and undisturbed conditions within Burns Bog with specific reference to ecosystem recovery following disturbance, hydrologic changes due to drainage, and broader ecosystems issues related to vegetation, wildlife, hydrology, soils and biodiversity. These discussions provided important contributions to understanding the factors crucial to preserving Burns Bog as a viable ecosystem.

The Environmental Assessment Office was assigned responsibility for managing the Burns Bog ecosystem review. They were responsible for coordinating all aspects of the review, identifying the specific technical studies required, facilitating the flow of information between interested parties including First Nations, tracking progress and ultimately reporting the findings of the ecosystem review.

2. THE SPECIAL NATURE OF A RAISED BOG ECOSYSTEM

What is a raised bog?

Burns Bog is a 'raised' or 'domed' bog, sometimes called ombrotrophic (rain-loving), a special type of bog that forms in mild, wet climates. Its estuarine and coastal location makes it rare, and in combination with its large size, make it almost globally unique.

The essential characteristic of a raised bog is its water mound, which acts somewhat like a single, large water bubble formed above the surrounding water table. The water mound is dependent upon the *Sphagnum* plants and the peat they form, and the peat and *Sphagnum* are equally dependent on the water mound. The water mound is formed within the peat, which like a giant sponge or wick, retains and stores the rain year-round. On the other hand, the *Sphagnum* which grows on the surface of the bog (think of it as the skin over the peat/water mound complex) is completely dependent upon the water mound for a water table which fluctuates just beneath the surface, allowing *Sphagnum* to survive dry periods through the year. Without this shallow water table, the *Sphagnum* would begin to die, leading to a process of decomposition, changing both the plants, and the hydrology.

In other words, in raised bogs, protection of the water mound is essential to protection of the ecosystem. Destroy the water mound, and the ecosystem ceases to be sustainable.

Raised bogs are different from other bog systems partly because they receive virtually all of their water from rainfall. Since rainwater is relatively free of minerals and other nutrients, raised bogs have a water quality that is low in pH (acidic) and minerals such as calcium, producing a characteristic signature that assists in determining the location of the functioning bog.

A relatively few specialized plants are able to thrive in such an environment. Raised bogs keep high water levels throughout the year and host plants (notably *Sphagnum* mosses) which prefer very wet and acidic conditions. The existence of the water mound therefore, is the main determinant of the type of plants found in this ecosystem. The plants and water in turn largely determine the type of insects and to a smaller extent the type of mammals and other animals to be found there.

An ecosystem like this, which receives its water supply and nutrients from the sky, is also unusual in another way. Water flow from a raised bog, as distinct from regular bogs, is generally outward. It does not depend, generally speaking, upon water flow from adjacent ecosystems. A raised bog is a year-round supplier of water to other ecosystems. In this important sense, the bog is an ecological island. Like other ecological islands, it tends to be both unique and sensitive.

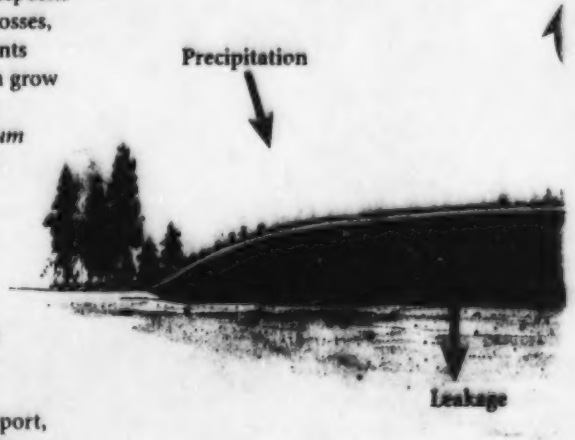
The peat-forming process is the defining characteristic of most bogs. Peat accumulates in bogs when the plant growth is greater than the plant decay in the wet bog environment. Peat deposits usually form from *Sphagnum* mosses, sedges or other water-loving plants growing in the bog. Sedges often grow during the earliest stages of bog development before the *Sphagnum* mosses, common in established bogs, begin to thrive. In Fraser Lowland bogs it is common to find *Sphagnum* peat deposits overlying sedge peat deposits.

An understanding of these basic processes is a key to understanding the reasoning behind the Ecosystem Review report, and its approach to answering the question of how much of the bog is required to ensure sustainability.

Raised Bog Hydrology

Several specific features are required for the functioning and survival of raised bog systems. These features, illustrated in the accompanying figure the basic oval shape of the bog; the dome-shaped profile with a raised core and sloping sides surrounded by low areas at the margin of the bog; a properly functioning unsaturated upper layer (acrotelm), and the ability to regulate water storage.

The basic oval shape of the bog with a raised core is essential to maintaining a saturated mound of peat and enough stored water to feed the bog plant communities driving the peat-forming processes. Because the core is raised above the surrounding landscape it receives nearly all of its water from rainfall. As the rainwater is soaked up by the upper layer of the peat mass, the bog fills, adding to the water mound, that like the bog itself is elevated above the regional water table. Water within the bog remains high because the dense lower peat layer (catotelm) and the impermeable deltaic silts at the base of the bog block the downward movement of water. Hydrologically, this feature

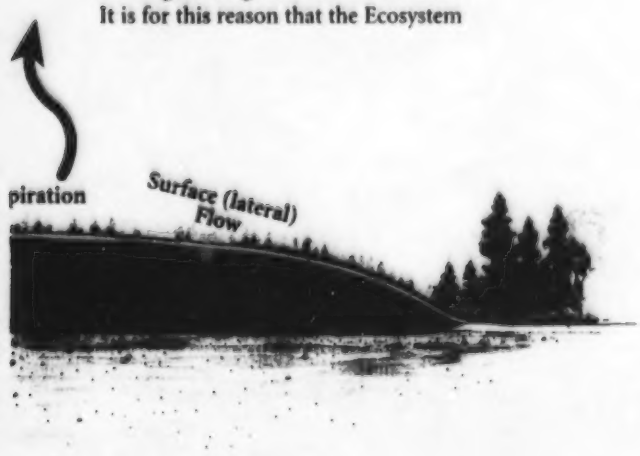


Raised Bog

isolates the bog, cutting it off from interaction with regional groundwater movement.

Water flows most freely through the upper layers of the bog surface within the zone of rooting and fresh peat decomposition. Excess water drains laterally through the upper layer passing through a narrow marginal zone on the sloping sides of the raised bog before feeding into a drainage zone on the periphery of the bog. Without this basic geometry and water storage capability, the peat-forming processes cannot continue and the bog will die.

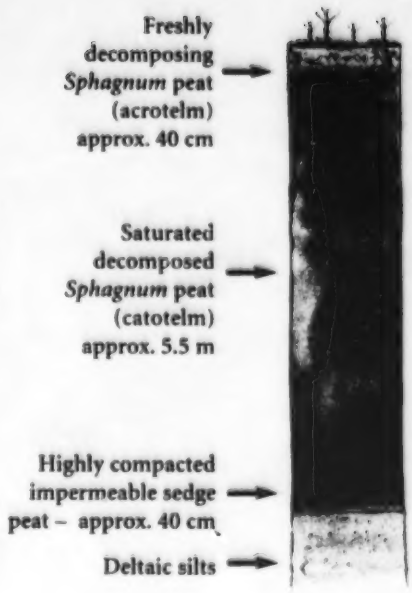
Water storage needs to be adequate to support peat accumulation and the associated plant and animal communities in the bog. Enough water needs to be stored to keep the water table in peat-forming areas from falling below a critical level during the summer drought period. Bog studies indicate if the water table drops for several years more than 30 to 40 cm below ground surface during the driest part of the growing season, peat-forming processes may not continue. The water storage capacity of the bog relates to the area available for water storage and the amount of water that is lost from drainage through channels or ditches. It is for this reason that the Ecosystem Review Report focuses upon the analysis of the drainage and the 'water balance' calculations.



Functional Layers in a Raised bog

Peat deposits in raised bogs occur in two layers. The upper layer contains peat made up of freshly decaying *Sphagnum* mosses and other bog plants. It is usually a thin layer, less than one-half metre thick, known as the 'acrotelm'. Water moves freely through the upper layer, which acts like a sponge, storing up rainwater during the winter and releasing that water for plant growth during summer.

The lower layer (the 'catotelm') contains thick peat deposits that have become compacted under their own weight and are full of the microscopic products of decay in the upper layer. Although this layer is always wet, water moves through it very, very slowly. As plants decay at the base of the upper layer they become part of the lower layer causing the bog to grow upward.


Freshly decomposing *Sphagnum* peat (acrotelm) approx. 40 cm
Saturated decomposed *Sphagnum* peat (catotelm) approx. 5.5 m
Highly compacted impermeable sedge peat – approx. 40 cm
Deltaic silts

Layers of Burns Bog

Effects of Drainage Ditches and Peat Removal

An understanding of the basic processes described above also leads to some clear implications in respect of threats to a raised bog ecosystem.

Drainage ditches lower the water levels in bogs creating the drier conditions required for peat harvesting and agricultural uses. Water levels are not only dramatically lowered near the ditch, but the drainage influence can extend far into the bog. These drainage changes have direct effects on bog vegetation and the process of peat accumulation. The drier conditions favour the growth of woody upland vegetation displacing typical bog plant communities. The woody trees and shrubs tend to use more water, further lowering water levels. With reduced water and increased shade from the growing tree and shrub canopy, the peat-forming plant community declines and peat accumulation stops. Eventually, the ecosystem processes cease to function and the raised bog dries.

PART 3. THE STUDIES AT BURNS BOG

To understand the puzzle of how and why the Bog works and the unique role of its physical and biological parts, an extensive series of technical studies were undertaken. The key findings of these studies provide some of the pieces needed to solve the puzzle. Completing this puzzle helped the Ecosystem Review to understand what the Bog needs to survive.

Hydrology (Water Balance and Water Movement)

Adequate water supply is key to maintaining a raised bog ecosystem. Climate, geology, natural drainage patterns, the plant community, wildlife and disturbances all influence the supply and movement of surface water and groundwater within the Bog system.

Hydrology is the foundation upon which raised bogs evolve and function to support the special flora and fauna that characterize them. At its beginnings, the growth of Burns Bog depended upon the poor drainage of the underlying silts deposited on the Fraser River delta. As Burns Bog developed, it became relatively independent of these and evolved as a large water-soaked peat mass, a hydrologic unit separated from the regional flow of surface water and groundwater.

Throughout its evolution Burns Bog has maintained the oval shape typical of raised bogs. The long axis of the oval developed parallel to the south arm of the Fraser River in a rougly east-west orientation and drainage features developed along this trend. This original configuration was the sustainable condition, and was probably related to development patterns of the Fraser River delta and underlying substrate. Despite significant modifications to the original form of the Bog, the modern shape is generally similar to the original self-sustaining configuration. A protection plan that maintains the original form and extent of the Bog area would be a prudent approach to preserving Burns Bog.

Prior to settlement of the area, water supply and flow met the needs of the Bog community. Winter rains filled the acrotelm and small pools, while surface water and seepage flowed outward from the raised centre of the Bog toward receiving systems along the margins. Reviews of topographic maps identify two broad high points suggesting two linked water mounds. One was located in the west central area and the other occurred as a partial dome or apron at the base of Panorama Ridge. Both domes stood as high as 5.5 m above sea level and were connected by a broad east – west oriented ridge from which water drained to the Fraser River and Boundary Bay.

Drainage ditches

Compared to its historic extent, today's water mound is a small north – south trending feature in the west-central part of the Bog. The steep slopes of the original water mound have been replaced by a large elevated plateau that gradually slopes eastward. This is the result of extensive peat removal during the past 50 years and has dramatically changed the dynamics of water retention and water flow within the Bog. To ensure the long-term viability of Burns Bog, the water mound must have the potential to return to its original form.

The EAO Report suggests a protection strategy that would include the discharge zone within a peripheral buffer zone to shelter it from additional human disturbances and enhance habitat development for wildlife at the edge of the Bog.

Vegetation studies indicate that the extent of the peat-forming plant community has been reduced in response to lowering the water table. In the 1930s, prior to disturbance, peat-forming plants covered 90–100% of the Bog indicating that a near surface water table was present throughout the Bog area. Today, these communities cover just 52% of the Bog area. These Bog communities continue to decline as woodlands encroach on areas once dominated by peat-forming plants.

One potentially serious concern is that the water table may drop to a level below which it cannot sustain the peat-forming community during drought conditions. The replacement of the peat-forming *Sphagnum* communities by woody vascular plants documented by researchers in Burns Bog indicates this change may already be occurring and will continue unless the original water balance is restored.

Profile reconstructions also confirm that the water mound is lower and less extensive than it was before disturbance and has shifted westward. Lower water levels are impacting plant community dynamics and are compromising the peat accumulation process that perpetuates the Bog's survival. Peat mining and ditch excavation have decreased the water storage in the Bog by lowering the natural water table and destroying large areas of the upper unsaturated layer (acrotelm). Air photos from the 1930s show few natural stream channels and an extensive pattern of ponds on the Bog indicating that water did not drain rapidly from the Bog. Comparing historic and modern drainage patterns reveals that only 15% of the Bog surface was influenced by drainage channels prior to disturbance compared to nearly 40% today.

Modern ditches differ from the natural channels because they are deeper and wider and are able to discharge a larger volume of water more rapidly. The Report prepared by the EAO demonstrates that this has significant implications for the water storage capacity of the Bog and average annual height of the water table.

Not only do the ditches rapidly drain excess water during the winter rains, but they continue to drain water during the dry season at a much higher rate than would naturally occur. As water is lost to drainage through ditches, the water table drops well below its normal level in large areas of the Bog. Water flow to the ditches continues until the average level of the water table drops below the depth of the ditch. This results in the water table falling below the 30–40 cm depth needed to maintain the peat communities during the dry season. In addition, larger ditches collect water from a larger area of the Bog, increasing their zone of damage to the ecosystem.

Recent studies document significant changes in the amounts of water and patterns of flow from Burns Bog resulting directly from peat mining and ditch excavation activities. These changes are not limited to the site of disturbance, but extend far into the Bog. The fundamental hydrologic changes that occur affect the extent of the wet peat-forming areas, the overall depth to the water table and the water mound position. These changes have significant consequences, influencing shifts in vegetation communities and ecosystem dynamics vital to Burns Bog. The replacement of peat-forming communities by woody vascular plants indicates that these changes are already occurring.

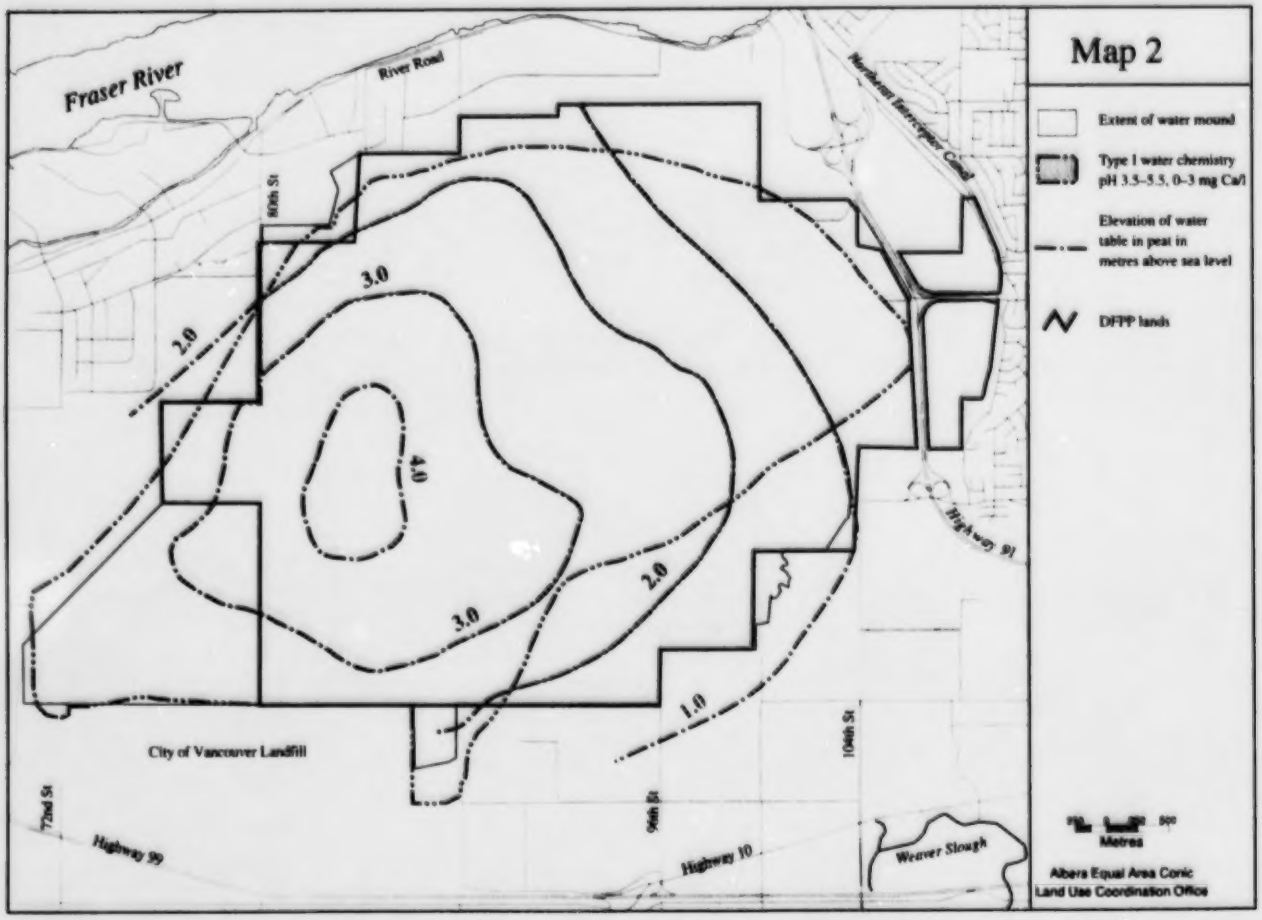
According to the Burns Bog Ecosystem Review Synthesis Report blocking the drainage ditches is one possible mitigation measure to decrease the outflow of water from Burns Bog. The extent and full effectiveness of these measures may not be known for several years and would require monitoring. However, it is anticipated that this would be the most direct and effective means to encourage recovery of the water table in the Bog. The long-term survival of the Bog's ecosystems depend upon the recovery of the water storage capacity of Burns Bog and a water balance where the loss from drainage through ditches does not add to evapotranspiration, the major source of water loss.

Burns Bog is characterized by highly acidic waters in the Bog core; this acidity sharply decreases as it moves away from the core through a transitional zone and the Bog margins (Map 2). The plants comprising Bog ecosystems are well adapted to the highly acidic water conditions. The historic extent of the peat-forming communities suggests that these acidic water extended over a larger area of the Bog. The acidic waters and the peat-forming communities that they nourish occupy a much smaller area today, reflecting the fundamental changes to the water chemistry resulting from human disturbance within the Bog.

Water Chemistry

The chemistry of bog water is ideally suited to the needs of the bog plant community. For plants, water brings food, supplying the nutrients needed for growth and the ideal balance of acidity that bog plants require to thrive. Changes in water chemistry can have dramatic effects on the bog ecosystem, causing plants adapted to bog conditions to be replaced by more aggressive species.

Water in raised bogs is acidic and nutrient poor. As bog plants decay, complex acids are released creating the low pH, acidic waters typical of raised bogs. This process also contributes to the high levels of organic carbon common in bog water. Low levels of minerals are also typical, as rainfall provides the largest source of water to the raised Bog and is nutrient poor compared to groundwater that picks up nutrients as it flows through mineral rich soils.



Map 2. Water mound/water chemistry

Plant Communities, Plants and Fungi

Burns Bog is home to rich and diverse plant communities. Before the mid-20th century, the Bog landscape was home to open heath and *Sphagnum* communities with shore pine and clusters of Labrador tea, Bog cranberry, salal and lodgepole pine. These peatland communities are the foundation of the Bog. Without them, peat will not form and the Bog ecosystem will die and with it the habitat for a diverse wildlife population.

Significant urban development since the mid-1970s has altered the Bog landscape, potentially threatening the stability of the plant communities and Burns Bog ecosystem.

Vegetation studies completed in 1981 and 1999 have documented the Bog's plants and plant communities. One goal of the 1999 study was to collect field data to identify parts of the Bog that are important to its long-term survival.

The 1999 inventory identified 24 different plant community types or ecosystems in Burns Bog. The types were grouped into seven forest ecosystems; nine shrub and herb ecosystems; and six poorly-vegetated ecosystems within areas of human disturbance

Burns Bog supports a diverse plant population consisting of 188 species of trees, shrubs and herbaceous plants, 53 mosses including 12 *Sphagnum* species, 16 liverworts, 94 macrofungi and 26 lichens

Forest Ecosystems

Three forest ecosystems occur near the margins of the Bog within a western redcedar forest and were probably present before European settlement. These communities generally grow on peaty soils and feature deciduous and mixed deciduous trees and shrubs intermingled with the western redcedar. Trees common to these ecosystems include red alder, vine maple, cascara, western hemlock and lodgepole pine. Salmonberry, salal, skunk cabbage, ferns and a diverse layer of mosses occur within these forest ecosystems.

The remaining four forest ecosystems developed in areas with evidence of changes caused by drainage or disturbance, primarily during the past century. Two birch and two lodgepole pine woodland ecosystems were identified. The lodgepole pine ecosystems cover slightly more than half (53%) of the Bog area, compared to birch woodlands which occurred on about three percent of the Bog.

Lodgepole pine and salal ecosystems occur around the margins of the Bog and on the Bog side of the birch and salal woodlands.

The Lodgepole pine and *Sphagnum* ecosystem includes important peat-forming plant communities. It covers nearly half of the Bog area (45%). Trees and shrubs vary in age as reflected in the height of the trees, and pines range in size from low shrubs to tall trees. Shrubby heath species such as Bog rosemary and Bog laurel are most abundant in the open shrubby areas. Among the tall shrubs and pines, velvet-leaf blueberry and salal are more common. *Sphagnum* mosses occurs throughout the community growing as large hummocky masses.

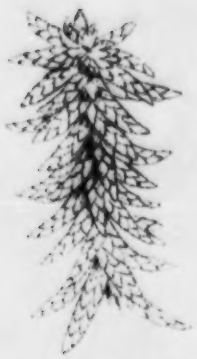
Birch woodland ecosystems occur near the Bog margins.

Labrador tea

Cranberry

Almost all of the forest ecosystems in the Coastal Douglas-fir biogeoclimatic zone within the Fraser Lowland have been listed by the provincial government as vulnerable, threatened or endangered because large areas have been cleared to support agriculture, urban and residential developments. As a result, the undisturbed mature woodlands in Burns Bog are classified as rare.

The Lodgepole pine and Sphagnum ecosystem could be considered as regionally rare because several plant species occur at their southern geographic limit for this plant community. These species include velvet-leaved blueberry, crowberry, cloudberry and Bog-rosemary. Because these species are growing at the southern limit of their typical range, they are also considered by experts to be genetically and ecologically significant.



Fat Bog moss

Shrub and Herb Ecosystems

Three shrub and herb ecosystems occur primarily at the Bog margins but together cover less than five percent of the Bog area – the hardhack shrub ecosystem, the reed canarygrass and hardhack ecosystem, and a bracken meadow ecosystem.

Six shrub and herb ecosystems were identified in the main body of the Bog. Only two of these, the White Beak-rush and *Sphagnum*, and the White beak-rush and Three-way sedge ecosystems covered relatively undisturbed areas and have also spread into areas of past peat mining. The remaining four ecosystems are limited to areas of past peat mining and include non-native species introduced by disturbance.

The White beak-rush and *Sphagnum* ecosystem covers nearly 14% of the Bog area, and is an important contributor to peat formation. It also occurs in undisturbed parts of the Lodgepole pine–*Sphagnum* heathland.

The White-beak rush and Three-way sedge ecosystem covers nearly 12% of the Bog area, occurring on sites where peat was mechanically removed and decomposed soils were left on the Bog surface.

Remnants of the original peat-forming ecosystems are symbols of the Bog's potential biodiversity. The peat-forming ecosystems once covered nearly the entire Bog surface but today have been reduced by half and are limited to within a narrow zone along the southern margin of the Bog and in the northwest part of the Bog. These undisturbed communities still host the original complex of plant and animal species but their narrow configuration makes them very vulnerable to disturbance and fragmentation. These pristine pockets are vital to the regenerating portions of the Bog and to its long-term survival. They must be preserved within a sustainable zone where they will enhance the recovery process by providing the source of plants, animals and micro-oorganisms to regenerating areas of the Bog.

White-beak rush

Greater Sandhill Crane

Sandhill Cranes are one blue-listed indicator whose habitat needs are linked to the peat-forming ecosystems. By examining their habitat needs we come a step closer to identifying the spatial requirements for habitat preservation. Sandhill Cranes require sites surrounded by open water for nesting with nearby areas for foraging and isolation from disturbance. Burns Bog provides habitat meeting these requirements. Habitat suitability mapping for the Greater Sandhill Crane in Burns Bog identified the areas of highest habitat value as the open heathland and white-beak rush dominated plant communities in the central western part of the Bog and other disturbed open habitats in the central area of the Bog. Areas of low importance habitat may provide a partial buffer zone to enhance recovery of declining populations and where possible an additional buffer zone of 250 metres is recommended outside the low importance habitat. The required area includes all of the western and central parts of Burns Bog.

Birds

Field studies for the Review covered several areas which looked at the occurrence and habitat use by waterbirds and birds of prey (raptors), the use of the Bog by the Greater Sandhill Crane, and listing occurrence all rare and endangered bird species using the Bog.

Greater Sandhill Crane

The Greater Sandhill Crane is a symbol of grace and beauty on the wing but also represents the plight of Burns Bog and the need for habitat preservation. The majestic cranes are not strictly Bog birds but need the shallow ponds and open areas of the Bog to nest and raise their young. Burns Bog is one of the few remaining areas in the Fraser River delta that provides suitable habitat.

The Greater Sandhill Crane is a provincially blue-listed (vulnerable) species. Wildlife experts recognize that the population of Sandhill Cranes in Burns Bog is highly significant regionally because breeding populations have declined or vanished elsewhere and populations have also declined in Burns Bog. In the Lower Mainland, the population is estimated to be between 20 and 30 birds, nesting in the Pitt Meadows area, Langley Bog and Burns Bog.

The Greater Sandhill Cranes of British Columbia are believed to be part of the Central Valley population including birds from northern California and southern Oregon. The cranes use Burns Bog from early April to mid-October.

At Burns Bog, a summer population of about eleven cranes is estimated to include three to four breeding pairs and two to three non-breeding individuals. The cranes prefer open heathland and wetland habitats near a pond complex in the northwest area of the Bog and the central Bog areas where the open habitats of white-beak rush and *Sphagnum* occur with small ponds and shrubby islands. In late summer and fall the crane population of Burns Bog increases as cranes disperse from other breeding areas in the Lower Mainland to use Burns Bog as a fall staging area. The cranes forage extensively in the nearby agricultural fields which provide an important food source during both spring and fall.

Waterbirds

Burns Bog is home to large numbers of waterbirds. During surveys conducted this year, 29 species were identified and the young of five species of waterbird were observed.

On a regional basis, Burns Bog provides habitat to some of the wintering duck population in the Fraser River delta. Surveys indicate the number of dabbling ducks using Burns Bog in winter could exceed 10,000.

Recent surveys have identified seven major species groups of waterbirds using the Bog. They include grebes, herons, three species of geese, ten species of dabbling ducks, six species of diving ducks, three species of coots and rails, and eleven shorebird species. Other notable species including Trumpeter Swan, Caspian Tern, several gull species and a Belted Kingfisher have been observed.

Burns Bog is not only an important nesting area for birds but also provides habitat for numerous migratory and wintering birds. Burns Bog represents one of the largest relatively undisturbed habitats in the lower Fraser River valley. Its size and limited access add to the value of this ecosystem. In the winter and spring, the large freshwater wetlands attract large numbers of waterbirds. These wetlands also provide important habitat in the fall before the winter rains have flooded the nearby farm fields. The Bog provides important roosting habitats for raptors such as the Barn Owl and for waterbirds such as the Mallard and Canada Goose. During breeding season, the Bog provides nesting and foraging habitats that are not available in the surrounding farmlands and unforested areas.

Rough-legged Hawk

Experts studying the area have identified three habitat types used by the waterbirds in Burns Bog. The habitat types were largely created by peat extraction and are distinguished by the annual duration of open water. Areas of permanent flooding provide year-round habitat and important areas for rearing young and are used by the largest number of waterbird species. Areas with persistent flooding provide valuable habitat during migration and spring territorial use. Areas of seasonal flooding are used mostly in the winter and spring when water levels are high, although they may also provide habitat for the night-roosting Canada Goose. Burns Bog is believed to play a role, the importance of which is yet unknown, in providing shelter for many of the Boundary Bay migratory waterfowl during storm events.

Raptors

Birds of prey use a wide variety of the habitat features in Burns Bog and all parts of the Bog are used by one or more raptor species. Early fall surveys within the Bog conducted for the Ecosystem Review identified eight raptor species and two owl species in the central Bog. Northern Harrier and Red-tailed Hawk were observed in equal numbers and accounted for two-thirds of the raptors sited during field surveys.

The EAO reports that as many as 13 species of hawks and eagles use the Bog annually. During the non-breeding season, raptors forage extensively within the Bog and use habitat suitable for roosting. During the breeding season, Burns Bog provides important nesting and foraging habitats that are not available in the unforested and actively cultivated agricultural lands surrounding the Bog. According to experts in this field, as many as eight or nine raptor species are thought to use the Bog forest habitats for breeding while one species nests in open habitat near the centre of the Bog. Open pond areas created by past peat mining attract Northern Harrier and falcon use, while Red-tailed Hawk use a broader range of habitat areas in the Bog.

Two owl species, the Great Horned Owl and the Northern Saw-whet Owl commonly roost in the pine and hemlock groves near open water. Northern Harrier, Cooper's Hawk, Red-tailed Hawk and Peregrine Falcon use the agricultural lands adjacent to the Bog for foraging. The provincially listed Barn Owl roosts in the forest ecosystems within the Bog, feeding on small forest-dwelling mammals but forages most actively in the surrounding farmland.

Rare and Endangered Bird Species

Two provincially red-listed (endangered or threatened) bird species, the Peregrine Falcon and Purple Martin are visitors to Burns Bog. However, experts consider these of low management concern because Bog ecosystems naturally lack suitable nesting sites for these species.

There are 12 provincially blue-listed (vulnerable) bird species occurring within the Bog. Of these, the EAO reports only four species with specific management concerns within the Bog: the American Bittern, the Great Blue Heron, the Greater Sandhill Crane and the Barn Owl. The survival of these species in the Bog depends in part upon protection of their habitats outside from continued damage and loss.

Mammals

Burns Bog hosts a wide range of mammals, particularly small mammals, yet our understanding of their distribution is limited by lack of systematic studies. During the Ecosystem Review, studies of small mammals and Black Bears were conducted. An examination of Black-tailed Deer was included in the Black Bear study because their habitat needs are similar.

Small Mammals

Studies of small mammals concentrated on creating an inventory of insect-eating mammals, rodents, hares and rabbits, and weasels in Burns Bog and adjacent lands. Deer Mice were the most common, accounting for 85% of all the small mammals captured in traps.

Two provincially red-listed (endangered) mammal species were confirmed in Burns Bog: the Southern Red-backed Vole and the Pacific Water Shrew. The Southern Red-backed Vole was a significant find in the Bog, as it's occurrence in British Columbia was previously known from only two specimens, the most recent of which had been collected more than 50 years ago. All of the Southern Red-backed Voles were collected in the pine woodland ecosystem with a dense understorey of salal found in the northwest portion.

The presence of the Pacific Water Shrew, a species provincially red-listed (endangered) and considered threatened by the Committee on the Status of Endangered Wildlife in Canada was also confirmed in Burns Bog. This species mostly uses the riparian areas and wetlands in the peripheral western redcedar forest where it prefers the sluggish streams and wetland areas within mature, old-growth forests.

Based on the trapping results, several ecosystems were identified as providing important habitat for small mammals in the Bog. Most of the small mammals were captured in mixed coniferous forests and shrublands of the western redcedar ecosystem and this ecosystem received the highest ratings for habitat suitability. Many other small mammals were captured in mixed deciduous forests and pine woodlands. Moderate habitat suitability ratings were given to the lodgepole pine and paper birch forested ecosystems and to the shrub and herb communities in the western redcedar forests.

Black Bears and Deer

The presence of Black Bears in Burns Bog has been confirmed through occasional sightings as well as positive identification of tracks and scat. These indicators suggest that bears are most active in the eastern and southern parts of the Bog, yet the number of bears using the Bog remains unknown.

Habitat suitability mapping used ecosystem data to identify areas that are potentially important as feeding grounds or cover. A limited area of the Bog was identified with suitable denning habitat for bears which require mature and old-growth forests found in some of the western redcedar and lodgepole pine dominated ecosystems.

Black-tailed Deer are relatively common in the Bog. Moderate feeding habitat were identified in the central parts of the Bog, however only limited cover and winter habitat is provided by forests at the Bog margins.

Black Bear

Southern Red-Backed Vole

The presence of the Southern Red-Backed Vole in Burns Bog is highly significant, as this is its only known occurrence in the province. In this context, habitat preservation is extremely important to the long-term survival of this rare species. The current distribution of the species is concentrated in specific areas making it particularly vulnerable to catastrophic events such as fire. All areas of high to moderately ranked habitat must be considered for preservation and expanded to include the many isolated pockets of suitable habitat. Required habitat areas would include pine woodlands on the northwest and western periphery and most of the class three habitat on the southern and eastern periphery of the Bog.

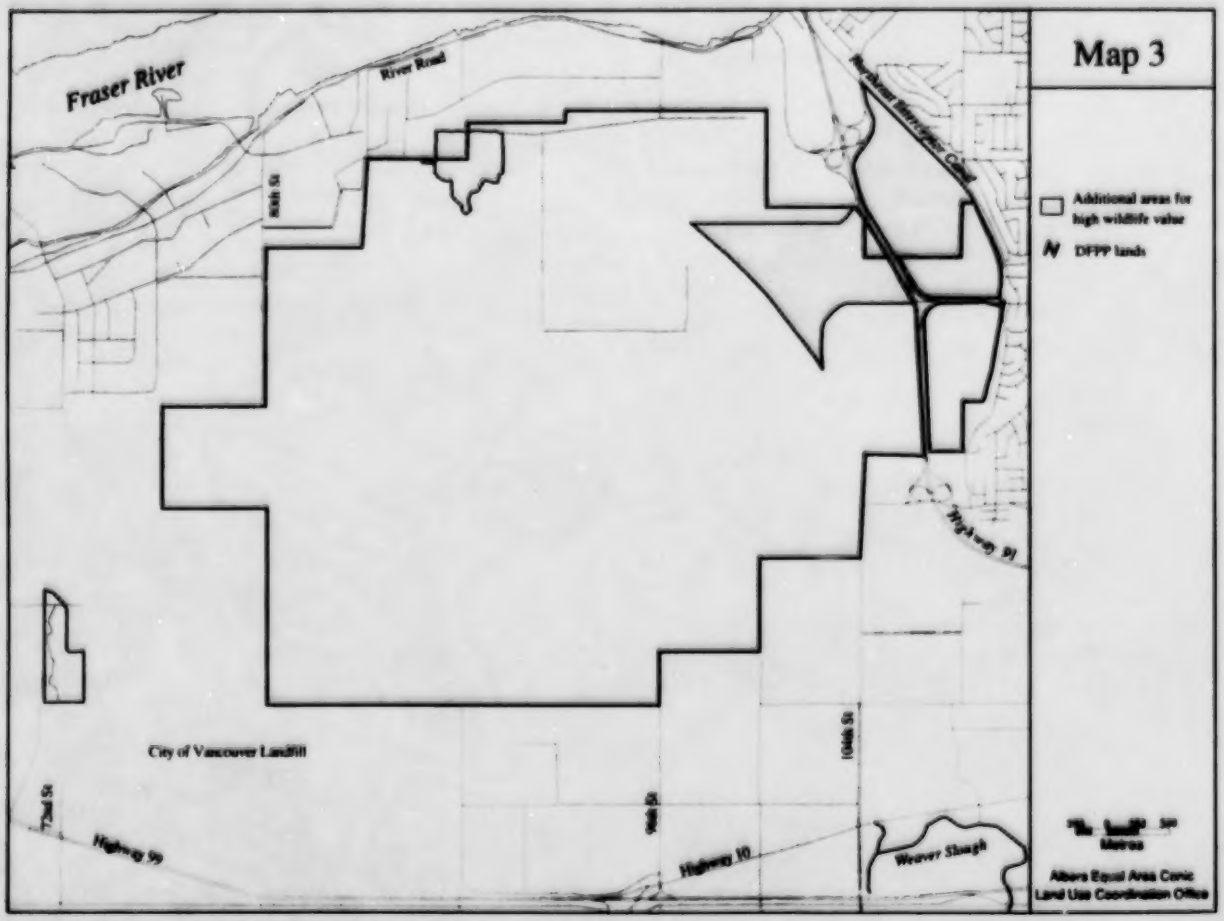
A comprehensive approach has been applied to identify areas of overlapping habitat requirements shared by groups of listed species. When applied to the listed mammal species, rare birds and amphibians a habitat mosaic begins to appear. The resulting mosaic includes forested ecosystems on the Bog margins that provide important mammal habitat, and highly ranked habitat for rare birds and amphibians, in the centre of the Bog (Map 3). Lands east of Highway 91 also provide important habitat for these three groups. The results of the analysis emphasizes the importance of both lands in the main part of the Bog and those ecosystems at the Bog margin and lands east of Highway 91 to sustain the wildlife diversity in the Bog.

Insects and Spiders (Invertebrates)

Surveys completed during the Ecosystem Review confirmed that Burns Bog hosts a diverse invertebrate population. Over 400 species were confirmed, but these likely represent less than 10% of the total invertebrate population.

Damsel fly

The consultants conclude that the aquatic habitats in the core of the Bog are likely to host the most distinctive insect population including the largest number of rare or potentially rare species that are specially adapted to the acidic water conditions. Nine rare or potentially rare insect species are known to occur in the Bog and aquatic habitats are important to five of the nine species, particularly during their early life stages.



Map 3. Additional areas of high wildlife value

Amphibians and Reptiles

Determining the presence or absence of red and blue-listed species was a primary goal of amphibian and reptile studies conducted during the Ecosystem Review. A list of 17 potentially occurring species was identified, including the following provincially listed species: the Oregon Spotted Frog, Red-legged Frog and the Rubber Boa.

Nine of the seventeen species were found in the Bog or areas adjacent to the Bog including the Red-legged Frog which is listed as vulnerable both provincially and by the Committee on the Status of Endangered Wildlife in Canada. The Northwestern, Western Red-backed, and Long-toed Salamanders, and the Tree Frog were among the native species observed. Two introduced species, the Green Frog and the Bullfrog were among the most commonly observed amphibians in Burns Bog.

Fisheries

Fisheries studies conducted at Burns Bog examined several key issues: water quality and the potential to support fish, areas of potential fish habitat, fish occurrence, and connections to fish-bearing waters. The study looked at potential fish habitat areas in the core of the Bog and the periphery. The Burns Bog core is not significant for its fisheries values.

Temperature, low pH, low levels of dissolved oxygen and isolation from fish-bearing waters were identified as habitat limiting factors for water bodies in the central part of the Bog. Fish were present only at periphery sites and included Carp, Threespine Stickleback, Northern Squawfish, Prickly Sculpin, Brown Catfish, Pumpkinseed and Goldfish. Coho Salmon, Chum Salmon, Cutthroat Trout and Rainbow Trout were confirmed in the Northeast Interceptor Canal and Watershed Park drainages. Due to their migratory nature, occurrence of salmon is dependant on connections with fish-bearing waters and connections are limited by existing diversion works.

Conservation Biology

Conservation biology provides a conceptual framework for habitat protection that can be directly applied to Burns Bog. It emphasizes that a larger area is better than a smaller area to enhance biodiversity and limit edge effects. Mapping of critical habitat for key species verifies the need for preserving not only the core of the Bog, but ecosystems along the margin of the Bog.

Secondly, the shape contributes to biodiversity and sustainability. The original east-west trending oval shape of the Bog was the naturally sustainable condition, protecting the core ecosystem including its plant and animal populations from edge effects. Today's pristine remnants are limited to a narrow strip along the southern margin of the Bog that is very susceptible to edge effects and disconnected in part from the hydrologic core of the Bog. Long-term sustainability of Burns Bog depends on the recovery of the hydrologic system and Bog ecosystems within the original outline of the Bog.

Thirdly, ecosystem connectivity in terms of dispersal or migration corridors for wildlife are important to the long-term sustainability of ecosystems. Corridors must be maintained or established to the Fraser River and Panorama Ridge uplands and an option for a corridor to Boundary Bay needs to be maintained.

The researchers identified prime amphibian habitat within the permanent ponds and riparian areas of the western redcedar forested ecosystems. These habitats provide suitable breeding areas and are likely to be important as juveniles and adults disperse form the breeding area. Maintaining these habitats will be important for sustaining the amphibian and reptile populations.

Northwestern salamander

Without drainage, Burns Bog has developed steadily and predictably for nearly 4000 years. However, drainage of the Bog through excavation of ditches and peat harvesting has greatly affected soil processes.

As areas of the Bog have been drained, the unsaturated and aerated upper peat layer (the acrotelm), has become thicker, causing peat decomposition to accelerate while peat-forming communities declined in response to drier conditions. This in turn has lead to the release of more nutrients into the soil, causing the expansion of woody plant communities and successful invasion into these areas by aggressive plants otherwise foreign to the Bog. This destructive cycle of drainage/soil change/plant change brings about still further changes in nutrient cycling and soil productivity until the structure and function of the original Bog ecosystem is gone.

Original soil conditions have been altered over large parts of the Bog through human activity. Today, typical undisturbed and developing Bog soils occur in much of the middle and southern third of Burns Bog. These areas should receive the highest priority for protection.

Geology

The geologic history of the Burns Bog area is a dramatic story of a landscape shaped by the advance and retreat of massive glacial ice sheets, changes in sea level, growth of the Fraser Delta and flooding on the Fraser Lowland. Each of these major events has left its footprint on the geology. Complex deposits of gravel, sand, silt and clay ranging from 300 to 800 m thick lie below the peat deposits of Burns Bog.

The near-surface geology in the Bog area resulted from glacial and river processes. During the last glaciation, the Fraser Lowland was covered by ice as thick as 1500 m. This great ice mass began to retreat sporadically about 13,000 years ago. Thick deposits of sand and gravel were left by glacial streams, and mixed deposits ranging from clay to boulder sized fragments were dumped by the receding ice masses.

By 10,000 years ago, the Fraser River began to deposit sands and silts in the vicinity of the Bog. Sand and silt deposits formed during periodic flooding of the Fraser River and changes in sea level. These relatively impermeable fine-grained deposits favoured the evolution of a wetland system by limiting drainage from this area. They provide the foundation upon which the Burns Bog ecosystem has evolved.

By approximately 5000 years ago, sea level was relatively stable This allowed the inland portion of the Fraser River delta to stabilize and the first plants of the evolving Burns Bog ecosystem to become established.

Soils

The core of Burns Bog consists of a thick saturated mass composed mostly of *Sphagnum* peat. This mass rises as a dome several metres above the surrounding landscape. It has taken thousands of years for this dome to form. It has taken only a few decades to threaten its survival.

The Burns Bog area has two broad types of soils—mineral and organic. Mineral soils occupy a smaller portion of the Bog area, occurring mainly near the periphery and in areas where human activity, mainly farming and peat extraction, have altered soil profiles.

The soils at the centre of the Bog are extremely acidic and have very low mineral levels. These extreme conditions are key to understanding life in this unique wet acid-based environment. Maintenance of these conditions is pivotal to sustaining the Burns Bog ecosystem as a whole.

Contaminated Soils and Surface/Groundwater

Industrial and urban development surrounding Burns Bog has increased dramatically since the 1970s. While several potential sources of pollutants were identified, no new testing was carried out to look at pollutants in the Bog. Industrial and commercial developments, the City of Vancouver Landfill and abandoned peat harvesting facilities within Burns Bog were mentioned. However, the likelihood of pollutants moving into the Bog from these areas is believed to be small because water mostly flows away from the Bog area. Within the Burns Bog ecosystem, toxins may leak from hog fuels used for road construction, sewage may leak from sewer lines, and chemicals and fuels may be released during accidents on roads and railways.

It does not appear that the presence of contaminants is a determining factor in identifying the areas needed for sustainability.

Conclusions of the Burns Bog Ecosystem Review Synthesis Report

General

- Burns Bog is a raised bog and has the typical characteristics of peat and water mound, radial drainage, acidic and nutrient-poor water and soil, and *Sphagnum* – heath-dominated plant communities
- Burns Bog is globally unique on the basis of its chemistry, form, flora and large size.
- Today the Bog is isolated from adjacent natural ecosystems by urban, industrial and agricultural development.
- Forty percent of the original bog area has been alienated by development.
- Peat mining and other activities have disturbed the hydrology and ecosystems of more than half of the remaining Bog. These disturbances continue to affect the Bog today.

Hydrology

- Precipitation is, and must continue to be the dominant source of water and nutrients in the Bog ecosystem.
- The Bog's water balance suggests a surplus of only 200 mm of precipitation over evapotranspiration for an average year.
- The Bog's ecological viability is directly dependent on the extent and integrity of the water mound and the peat that encloses it.
- Further disruption of the water mound poses high risk to the integrity and viability of Burns Bog.
- The upper porous layer or acrotelm is vital to the persistence of the water mound and peat-forming communities. The existing area of acrotelm must be maintained and a fully functional acrotelm must re-develop over the area of the water mound.
- Little of the essential lagg zone remains in an undisturbed state. A fully functioning lagg must occur at the margins of the water mound.
- Ditches drain water in excess of normal discharge leading to a decrease in water storage and in the critical summer water-table position threatening the Bog's viability.
- The water-chemistry of the majority of the Bog is acidic and nutrient-poor, typical for a raised Bog. It provides a useful guide for identifying areas required for viability.
- Transitional waters are required to separate typical Bog water from adjacent mineral water.
- Water from the east side of Highway 91 may play an important role in sustaining shallow pools that support the main water mound.

Biota

- The undisturbed plant communities that occur in the southern third and in the north-west sector of the Bog are vital to its survival.
- The Burns Bog area includes several nationally and provincially listed animals such as the Pacific Water Shrew and plant communities in both the core central area and at the margins.
- Burns Bog harbours the only known habitat for Southern Red-backed Vole in the province, and critical habitat for the regional Greater Sandhill Crane population.
- Rare insects occur in the distinct wet habitats of the bog.
- The Bog plays an important regional role in ecological and wildlife diversity by providing habitat for Fraser River estuary waterfowl, maintaining the largest extent of Bog ecosystems in the Fraser Lowland, and harbouring several species at their southern limits of geographic range.

Processes

- The expansion of forest communities indicates that the bog has been and is drying because of drainage by ditches.
- Widespread *Sphagnum* regeneration is occurring in the abandoned peat workings of the central bog.
- The Bog area is highly sensitive to fire and must remain large to be viable under the current fire regime.
- Three drought years could markedly lower the position of the late summer water table to a point where it may not support typical Bog communities.
- Connectivity is limited, but must be maintained for the long-term viability of the Bog, especially its wildlife.
- Exotic species occur on disturbed peat but do not occur in undisturbed vegetation to any extent.

Viable Area

- The water mound zone and its peripheral lagg are required for ecological viability.
- The area east of Highway 91 and north of 72nd Avenue is required to support high biodiversity attributes, to provide water to the main part of the Bog west of Highway 91, and to connect the Bog to upland habitats.
- The water mound zone must be connected to the area east of Highway 91 via a broad zone of *Sphagnum* regeneration and typical bog water. Water in the shallow ponds within this zone supports the water mound.
- Ditches that drain the water mound zone must be blocked as soon as possible to support the water mound and peat-forming processes or the Bog will continue to shrink and will not be viable.
- A program of ongoing monitoring of key indicators of ecosystem integrity is essential to determine whether required ecosystem characteristics, such as the hydrologic regime, remain intact.

Considering the preceding conclusions, approximately 2,450 ha of the 2,800 ha of ecologically available area are required to preserve the ecological integrity and viability of Burns Bog and sustain its distinct processes and lifeforms. By maintaining an area of this size, monitoring key indicators, and adjusting management action, this globally unique ecosystem has a reasonable likelihood of persisting long into the future.

PART 4. DISCUSSION

The consultant studies and the analysis in the Ecosystem Review Report make it clear that the health and location of the water mound is the key determinant in the ecosystem dynamics in Burns Bog. The best mechanism for protecting ecosystem viability is to protect the water mound.

Not surprisingly, the report finds that there is significant overlap between the areas required to protect the water mound, and those areas required to protect the habitat of the Sandhill Crane and important waterfowl species. However, additional areas will be required to protect other wildlife values not associated with the water mound.

Because of the importance of the water mound, and the importance of healthy *Sphagnum*-producing conditions, the characteristic water chemistry associated with *Sphagnum* Bogs – low pH and low calcium – is a significant guide to identifying the location of the water mound. The signature water chemistry, however, is not entirely coexistent with the water mound, since it is also associated with *Sphagnum*-producing areas that no longer form part of the water mound.

Adapted from the Ecosystem Review Report, Map 2 shows the present location of the water mound as determined by the EAO. Contour lines are provided to show the shape of the present mound, and show its centre in the west area.

The Bog's original outline was, and still largely is, an oval or ellipse. The Ecosystem Review Report finds that this is not a chance feature, and that a conservative approach to ecosystem viability requires that we attempt to maintain that shape, and the general configuration. Wherever possible, a regular shape should be sought, to minimize edge effects.

For a Bog to be sustained in the long term, the report also makes clear that the three structures associated with the water mound must be present:

- the dome or plateau
- the 'narrow rim' or transition zone called the rand
- the lagg zone, where the excess water collects and drains away.

The maps shown in the Ecosystem Review Report, and this map, attempt to describe the water mound in a sufficient size to enable those three structures to be present, and to include a small buffer zone.

The attached Ecosystem Review Report confirms in its discussion of hydrology and the water balance equation that the existing Bog is shrinking. The combined effects of a half century of development, 40 years of peat harvesting, and the current, ongoing drainage ditches have taken their toll on the Bog. The shallow water table required for a functioning Bog had declined from 90–100% in the 1930s to 52% of the area today. The overall water storage has declined by 60% (84 million m^3).

Any further disturbance of the water mound, through peat mining, cranberry farming or traditional development, has the potential to significantly affect water levels through its impact on the water mound. I have reproduced Figure 6.1 from the Ecosystem Review Report to show how even minor disturbance or development on the edges of a water mound can have a geometric or disproportionate impact on the whole of the Bog. As the water table lowers in the centre to compensate for effects on the edge, vegetation is affected throughout the Bog. The report notes that a permanent decrease of water table of only 10 to 15 cm over a few years can have significant vegetation impacts.

The significant fact is that the consultants' reports found, and the Ecosystem Review Report confirms, that this change is currently ongoing in the Bog. The centre of the water mound has been shifted westward. The extent of the water mound is much less than it once was. Plant community dynamics suggests that it is still shrinking. This leads to the clear conclusion in the report:

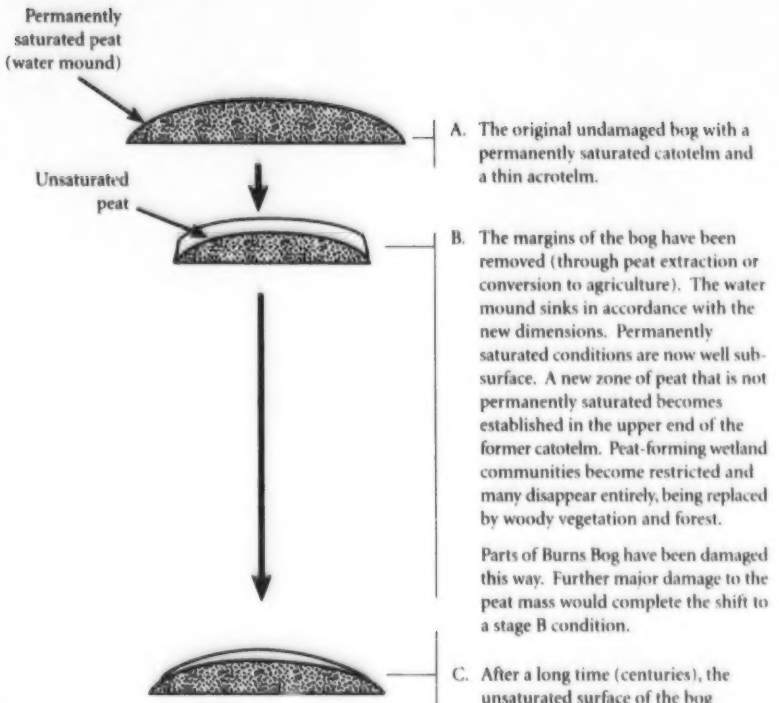
> ***"Given these considerations, the Bog's water mound cannot undergo any further loss if the Bog is to remain viable."***

That conclusion has significant implications for the approach to the Terms of Reference requirement to assess the areas critical to sustainability. It takes us beyond the question: How much of the existing Bog can we afford to lose? It implies that the proper question is: How much have we already lost, and can we afford to lose any more?

The detailed and comprehensive assessment by Dr. Hebda, the EAO Team and the International Consulting Scientists leads to a conclusion that there is little room to maneuver. This is no longer a healthy functioning Bog that may be able to sustain itself while it loses only 10 or 20%. The conclusion is that sustainability of this special ecosystem requires that **we must maintain all of the existing functioning Bog.**

In other words, the hydrological evidence and the vegetation evidence clearly established that the area required to be protected to ensure the sustainability of the Bog, as directed by the Terms of Reference, is at least the area contained in Map 1.

On the other hand, the extent of development outside the Bog, the existence of the Vancouver Landfill on the southwest corner, the industrial development of River Road and the extent of forest development on the periphery, precludes any real likelihood that the functioning Bog and its water mound can ever be restored to its original size, at least in the short term and without massive expense and social relocation. This means there is little value, in a hydrological sense, in protecting more land than the existing water mound, its rand and lagg requires, and what can reasonably be expected to expand. (We must also protect buffer zones; the Ecosystem Review Report has taken this need into account). Protecting peat lands that were formerly part of the Bog outside of these areas may have green space and wildlife values, but will not contribute to the sustainability of the raised Bog ecosystem.


Permanently saturated peat (water mound)
Unsaturated peat
A. The original undamaged bog with a permanently saturated catotelm and a thin acrotelm.
B. The margins of the bog have been removed (through peat extraction or conversion to agriculture). The water mound sinks in accordance with the new dimensions. Permanently saturated conditions are now well sub-surface. A new zone of peat that is not permanently saturated becomes established in the upper end of the former catotelm. Peat-forming wetland communities become restricted and many disappear entirely, being replaced by woody vegetation and forest.
Parts of Burns Bog have been damaged this way. Further major damage to the peat mass would complete the shift to a stage B condition.
C. After a long time (centuries), the unsaturated surface of the bog gradually wastes (through peat oxidation and decomposition) towards the zone of permanent saturation.

Changes in badly-damaged peat remnants subject to natural processes of peat decomposition. Changes to stage C are likely to take place very slowly (adapted from Wheeler and Shaw 1995 and excerpted from the Ecosystem Review Report).

For those species of plant, animal and insect life that depend upon and are associated with the Bog ecosystem, many of which are rare and possibly unique, the Ecosystem Review finds it would not be enough to protect the existing pristine areas of vegetation along the south. These few remaining areas are now subject to a significant edge effect, and are drying in such a manner as to be at risk. However, protection of the water mound in whole, in addition to these pristine areas, should ensure that this rare and unique biota are protected.

Many of the other rare or endangered species, including the Greater Sandhill Crane, the Southern Red-backed Vole and the Pacific Water Shrew, may not depend directly upon the Bog ecosystem

but have habitat needs that are co-existent with the water mound described in Map 2. Protection of these species is also addressed through protection of the water mound.

There are, however, additional areas that have significant wildlife and biodiversity values, that are distinct from those found within the acid-based *Sphagnum* Bog ecosystem. The most significant of these are found east of Highway 91, and north of 72nd Avenue in the vicinity of the present Delta Nature Reserve.

Although the definition of the Bog 'ecosystem' was not provided within the Terms of Reference, there is no doubt that the large mammal and forested values associated with this area are considered by the public to be part of the Burns Bog ecosystem, and should be protected.

The Ecosystem Review Report uses a biodiversity approach to analyse sustainability issues. This approach considers three components of biodiversity to identify the ecosystem dynamics and habitats vital to the survival of Burns Bog. They include:

- preserving the remaining natural Bog community;
- using indicators, such as listed species and keystone species; and
- applying principles of Conservation Biology to small populations.

It is also not enough to simply protect the Delta Nature Reserve and the additional area of Delta Fraser Properties beside it to 72nd Ave. If these areas were cut off from the larger water mound ecosystem to the west of Highway 91, an isolated island would be produced which could be significantly jeopardized. Accordingly, the area between the water mound and the Delta Nature Reserve is recommended for protection, primarily for connectivity purposes.

In addition, hydrological data also suggests that there is a flow of water from the area of the Delta Nature Reserve under Highway 91, which pools to the west of the water mound, outside of it, but contributing to the overall water balance sustaining the water mound. Accordingly, there are hydrological reasons to protect that area as well as connectivity.

The total areas recommended for protection over and above those required for the water mound to the water mound for wildlife, connectivity and hydrological contribution are shown in Map 3.

In combined summary, the area therefore recommended for protection is shown on Maps 1 and 4. This area totals 5920 acres (2400 ha) in public and private lands. The Delta Fraser Properties lands consist of approximately 5000 acres of this total. It is this amount – 5920 acres – that most clearly answers the question posed in the Terms of Reference, based on the information we have before us.

The Ecosystem Review Report also considers, as an alternative approach, the impacts of conservation biology and a disturbance analysis. Questions of size are not just a matter of location of species and ecosystem dynamics. Population viability often has a direct relationship with size, particularly in island-like ecosystems such as Burns Bog. Further, random disturbances such as drought, fire and invasion by exotic species can have catastrophic effects on species populations or ecosystems that are otherwise balancing on the edge of viability. To be viable, an ecosystem must be large enough to withstand such disturbances as can reasonably be foreseen.

The disturbance modelling applied by the Ecosystem Review Report did not independently determine the areas required for protection (which were reached primarily through hydrology and wildlife approaches), but instead is used to confirm that the recommended size is sufficient, and to conclude that any significant reduction in size has the potential to result in dramatically adverse impacts.

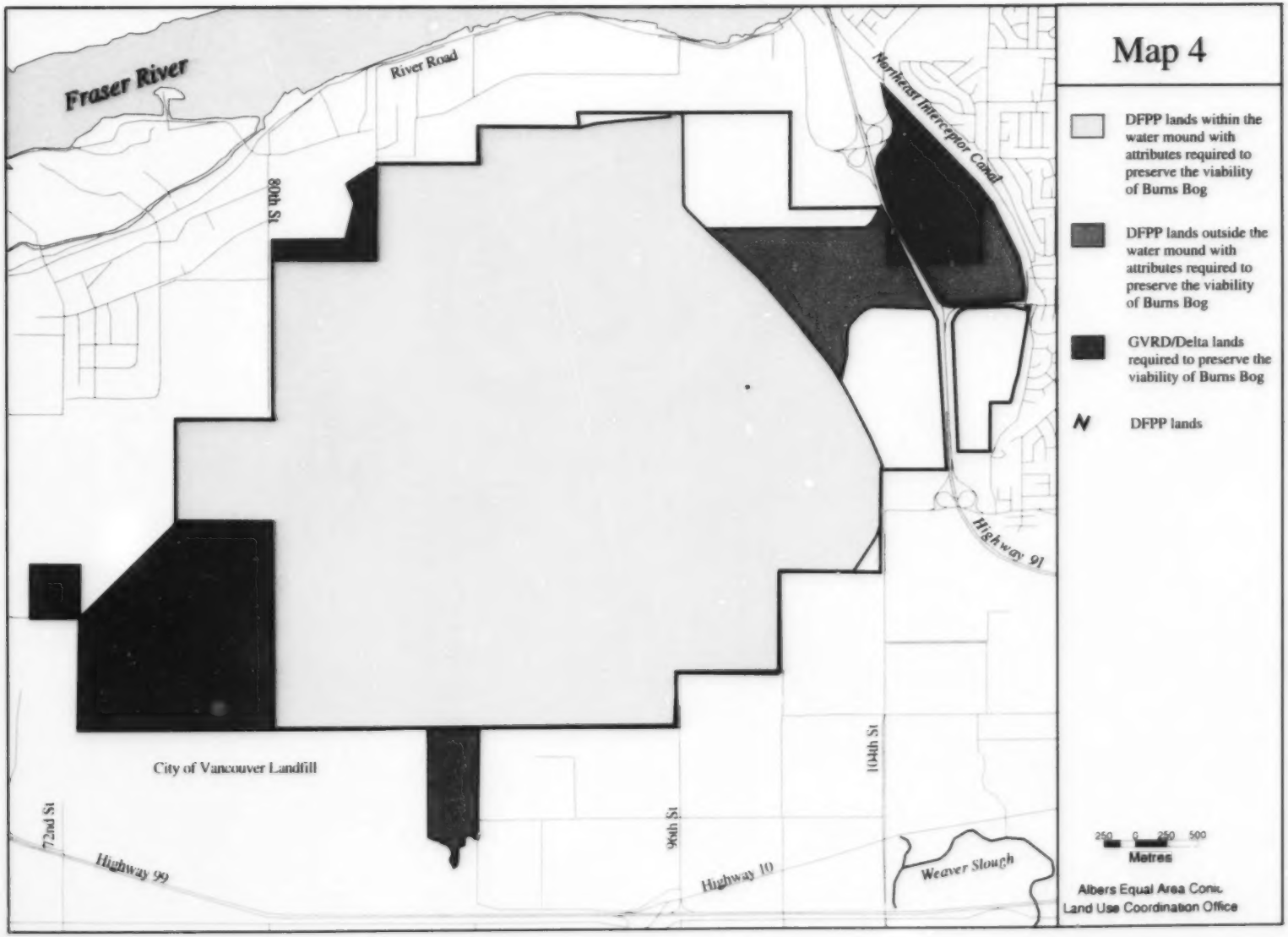
The fire modelling showed that a reduction in size by even 25% posed a considerable risk to long-term viability. Even on the recommended size, fire damage is likely to contribute (over the next 100 years) to a continuing overall reduction in the area of mature peat-forming communities before the Bog begins to fully recover. As well, an ongoing risk from catastrophic fire continues to exist (although it can be mitigated by reducing drainage impacts).

Similarly, in drought modelling, the Ecosystem Review Report determined that the best protection from drought affects was a large and active peat-forming acrotelm (which helps to maintain a satisfactory water table). At its existing size, the Bog is at significant risk should there be an extended three year drought. Any significant reduction in size will increase that risk unacceptably.

In summary, the Ecosystem Review Report attempts to combine these approaches and concludes that:

> ***"Taking a cautious approach, the total viable area must be in the upper part of the 1980–2610 ha range."***

Accordingly, the recommended area of 5920 acres (2400 ha) should reasonably meet those concerns, allowing for reasonable caution and some margin of error.


Map 4
DFPP lands within the water mound with attributes required to preserve the viability of Burns Bog
DFPP lands outside the water mound with attributes required to preserve the viability of Burns Bog
GVRD/Delta lands required to preserve the viability of Burns Bog
DFPP lands
N
250 0 250 500
Metres
Albers Equal Area Conic
Land Use Coordination Office
Fraser River
River Road
80th St
Northeast Interceptor Canal
Highway 91
City of Vancouver Landfill
72nd St
Highway 99
96th St
Highway 10
104th St
Weaver Slough

Map 4. Lands required to preserve the viability of Burns Bog

PART 5. THREATS TO BURNS BOG

The Burns Bog Ecosystem Review clearly indicates that fundamental changes are occurring to processes critical to sustaining the Bog's ecosystems. Approximately 5500 acres (2200 ha) of the Bog remain zoned for development. The existing Bog is shrinking, and changing in ways adverse to the existing ecosystem.

Although Burns Bog remains a special place, and would remain one even if the ecosystem were to change, unless action is taken now or very soon, the survival of Burns Bog as a raised bog ecosystem is in jeopardy.

Specific threats to the Bog fall into four main categories: changes to Bog hydrology resulting from human disturbance; increased vulnerability to fire; the risk of habitat loss; and continued cranberry farming and peat mining. The Ecosystem Review examines each of these areas, and describes some immediate and long-term threats to the Bog. These threats have implications for both the immediate policy decisions now before government, and long-term management considerations.

Drainage and Hydrologic Changes

Fundamental changes to bog hydrology have occurred as a direct result of increased drainage from the Bog. Extensive networks of ditches have been excavated to support cranberry farming and historic peat mining. In 1930, approximately 43 kilometres of ditches drained about 17% of the Bog area compared to at least 110 kilometres draining nearly 40% of the Bog area today.

The ditches are directly responsible for altering the water balance and water flow patterns within the Bog – features that are critical for maintaining the Bog's viability. Increased drainage has demonstrably lowered the water table, thickening the acrotelm and increasing decomposition. The consequences of altered drainage patterns and a lower water table in Burns Bog has resulted in reducing the height and extent of the water mound and shifting it west of its original position. The drier conditions this creates favour establishment of woody plants. Vegetation studies clearly demonstrate that forest ecosystems are expanding at the expense of the peat-forming plant communities. As the drier conditions persist and traditional Bog plant communities dwindle, *Sphagnum* growth and peat formation cease.

Restoring the hydrological dynamics to the Bog is identified by the Ecosystem Review as a high priority. Blocking many of the ditches that currently drain the Bog is the first and most obvious solution. The most critical ditches are those that extend into the centre of the Bog. Ditches on the outskirts are less harmful, and in some instances, carry out functions similar to the original lagg drainage. Fortunately, the vegetation studies suggest that native plant communities will regenerate over the long term, in response to recovery of the water supply and water flow regime in the Bog. As the plant communities recover, the original ecosystem dynamics and biodiversity should be restored.

These water balance/drainage issues can most easily be addressed if the essential portions of the Bog are purchased by government. If purchase of these areas cannot be achieved, it is recommended that government seek the cooperation of the landowners, or failing that, consider a regulatory solution dealing with protection of the water table and drainage within the central Bog area.

Fire

Development within and adjacent to the Bog has significantly increased the frequency and magnitude of fires affecting Burns Bog. Increased drainage has dried out the Bog in certain areas and seasons, increasing the likelihood of fires starting. Woody trees and shrubs are replacing the peatland communities because of drainage and provide additional fuel to promote rapid spread of fires.

Fires can have a devastating effect on the ecosystem, rapidly destroying plant cover and part or all of the underlying acrotelm. The *Sphagnum*-dominated plant communities, essential to the peat-forming process are the most vulnerable to the fire damage. Following fire, the barren burned sites, become wetter and more enriched in nutrients causing dramatic changes to the ecosystems, eliminating natural Bog plant communities and displacing or eliminating wildlife species. Opportunities for invasion by exotic species also increase. Vegetation studies within Burns Bog specifically identify several invasive plant species that are actively displacing native plants in fire damaged and other disturbed areas.

Although fire is likely a natural part of any ecosystem, and so likely has a positive ecological role in a healthy Bog, the extent to which the current Bog has dried out from human activities creates a real and non-natural risk. It will be appropriate (though perhaps difficult) to consider intervention to regulate fires in the short term.

The Ecosystem Review discusses the risks of fire as a significant risk to the long-term sustainability of the ecosystem. Improving the water balance and drainage control may reduce the number and size of fires. Most importantly, however, the risk of fire is a determinant suggesting the need for a larger protected area to reliably assure survival in the long-term future.

Habitat Loss

Changes to the hydrology of the Bog and increased vulnerability to fire have resulted in quantifiable shifts in plant communities. Shifting plant communities and ecosystem dynamics are accompanied by significant changes to habitat. The open peat-forming communities and heathlands at the centre of the Bog provide critical breeding, shelter and forage areas for a diverse range of amphibians, invertebrates and bird species including the vulnerable Greater Sandhill Crane. However, vegetation studies demonstrate that woody trees and shrubs are encroaching on these traditional Bog communities. Without these specific habitats, the survival of the many species they support is threatened. Each of the plant communities native to the Bog provide important habitat for a diverse range of life forms from micro-organisms to large mammals. Habitat loss has direct implications for biodiversity within the Bog.

The ecosystem review used three approaches to identify areas of critical habitat. These approaches consider habitat protection for individual species listed as threatened or endangered, habitat areas required for ecological viability, and habitat areas with high suitability for a diversity of wildlife types. This approach produced a mosaic of ecosystems including much of the historic Bog area, with attributes important to sustaining biodiversity and ecological functions within Burns Bog.

The potential impacts on habitat loss can only be determined by protection of a large area, as recommended by this report.

Cranberry Farming/Peat Mining

Current zoning allows cranberry farming and peat-mining. Both activities result in stripping of the acrotelm, which severely alters the functioning of the ecosystem. As noted above, these impacts can be disproportionate to area. Any further cranberry farming in the critical areas for sustainability identified in the Ecosystem Review is therefore destructive to ecosystem sustainability. Cranberry farming cannot co-exist in the water mound area with the ecosystem processes that have been determined as being on the edge of viability. New cranberry farms in this area should be avoided.

However, cranberry farming relies generally upon wet conditions, and so otherwise should not have adverse hydrological impacts if conducted reasonably, outside but adjacent to the critical Bog areas, in the areas where it is currently operating.

Part 6. Public Comments

Extensive public comments were received throughout the Ecosystem Review directed to the EAO, and to myself, as well as to the Minister of Environment. Most of these public comments advocated protection of the Bog, and made it clear that the Bog was considered to be a special place. A selection of these public comments is attached as Appendix 1. The majority came from the Lower Mainland area of B.C., including many from outside Delta.

In general, the public consultations focused upon three arguments for the protection of Burns Bog:

- a unique and endangered ecosystem (the raised or domed Bog dependent on hydrology and *Sphagnum* growth and peat formation);
- a home to wildlife – both vulnerable or rare, and those that might be more common (but still deserving of protection);
- a substantial green space in an urban environment.

Each of these qualities raises different considerations and constraints. Each is important in its own way. The recommendations proposed here deal with all three aspects.

Many public submissions, however, were unwilling to recognize that there might be ecological distinctions within the remaining undeveloped lands and urged us simply to protect it all. Some based this argument upon the proposition that too much had already been lost.

Some other issues upon which the public focused their comments turned out to be less well established by the science and consultants reports in this Review:

- air quality control (the 'lungs of the Lower Mainland');
- fisheries; and
- water purification (the 'kidneys of the Fraser River').

In respect of air quality, many submissions referred to a purported role of the Bog of purification of air in the Lower Mainland. Some referred to its function as a carbon sink, and a positive factor in greenhouse gases. Despite one consultant's study aimed at this issue, the Ecosystem Review was unable to establish such a clear link. There is no doubt that Bogs of this kind have a great deal of carbon stored within them (through 5000 years of peat accumulation). However, Bogs also generally accumulate carbon at a very slow rate (much slower than other forested ecosystems for instance), particularly in its mature phase. Our study could not establish a net positive carbon-storing contribution at this time. In fact, given the drying trend within the Bog, it is possible that the rate of decomposition exceeds the rate of new growth, and that the contribution of the Bog is at best neutral, considering the emissions of methane. In the end, we had inadequate data to make firm conclusions but it is unlikely the Bog plays any significant role in air quality either way.

In respect of water purification of the Fraser River, our study also produced little support. In its current state, the Bog is effectively blocked from the Fraser River, and there is practically no interchange of water. Any interchange would be miniscule in any event, relative to the volumes flowing in the Fraser River. Further, in terms of ecosystem functioning, two essential characteristics of ombrotrophic Bogs such as this one are the dependence on rainwater, and the lack of nutrients. Any large flow from the Fraser River would bring with it nutrient-rich waters which would significantly change the vegetative balance.

In respect of fisheries, the Ecosystem Review was unable to confirm any salmonid benefits of significance. The acid-based nature of the majority of the central Bog is not conducive to most fish, and the studies found no fish in these areas. There were some fish species on the periphery of the Bog, but not in areas that could be described as being rich in fish values, except in the Northeast Interceptor ditch. There is no evidence of effects on fish in the Fraser River.

Nevertheless, it should be noted that most public comments that made the above justifications mentioned other significant justifications for protection that have been confirmed. In some cases, it would seem that there is strong generalized will for protection, which may precede the formulations of arguments to government to justify it. A great deal of the public desire for protection might be said to be emotive, but is no less strong because of that. The public will for protection is very real.

PART 7. SOME MANAGEMENT IMPLICATIONS

Form of Protection

The proposed protected areas are located entirely within the Corporation of Delta, and therefore within the GVRD.

If all levels of government participate in the protection of Burns Bog as public land, it will be necessary to determine how this will be structured, who will hold title, and how it would be managed. Given the sensitivity of multi-government processes, it is essential to be flexible in approach. In this instance, it is far less important how title is held, than that the Bog be protected. It may be necessary, to achieve varying governmental objectives, that a mix of approaches be used.

With that proviso, I believe that the preferred approach, if satisfactory to all governments involved, would be to have the bulk of the new protected areas managed by the GVRD, based upon a long-term (99 year) renewable lease, with the underlying title held by the Province of British Columbia.

Delta currently owns and manages a parcel of land on the east side of Highway 91 as the Delta Nature Reserve. This land is much loved by the public, and has been developed sensitively with boardwalks and other trails. Subject to Delta's wishes, it may be more sensible to have that land remain as Delta land, and to have the small parcel adjoining it, north of 72nd Avenue, acquired by Delta to form part of it (see Parcel 2, Map 5).

Parcel 8 and 9 on Map 5 adjoining the Vancouver Landfill, are currently the property of the City of Vancouver, but are scheduled to be transferred to Delta as park land under the Vancouver Landfill Agreement. Parcels 10 and 11 are Corporation of Delta lands. Accordingly, the approval of both the City of Vancouver and the Corporation of Delta would be required to deal with these lands. Given the findings of the ecosystem review that these lands are part of the core water mound lands critical to the survival of the Bog, it seems most appropriate that these lands be managed under the same regimen as the remaining lands. Accordingly, depending on the wishes of Delta and Vancouver, they should be leased to the GVRD under the same terms as the remaining lands. Alternatively, if Delta wishes, these lands could remain in Delta's hands, to be managed as part of the Delta Nature Reserve. Because of the sensitivity of the land, and its location near the south-west centre of the water mound, it is important that Parcel 9, 569 acres (231 ha) be managed mostly as ecological reserve.

It is not uncommon to have multi-government structures involved in the management/ownership of park land. Stanley Park is currently managed by the City of Vancouver under a 99 year lease from the Government of Canada, as is Vanier Park in Kitsilano (the Planetarium lands). A number of areas in the Fraser River and Boundary Bay recently purchased as part of the Georgia Basin Initiative are part of a similar joint arrangement between the Province of British Columbia and GVRD. In fact, a joint arrangement such as this, since it would then take the consent of two governments to vary, provides greater long-term protection for park land.

Public Access

This *Sphagnum* based Burns Bog ecosystem is extremely fragile. Even foot traffic can harm the delicate micro-systems characteristic of the Bog, particularly in the central areas. Other bird and mammal species, and notably the Greater Sandhill Crane, are extremely wary of human contact, and may live in the remote central portions of the Bog for exactly that reason. Other mammal species are particularly vulnerable to humans with their dogs and foraging cats. There are also some portions of the Bog that are difficult or dangerous for unskilled users.

Although an area as large as the Bog can sustain, and has been sustaining, some limited human visits, it is also clear that the ecology of Burns Bog cannot sustain the degree of human use of other Lower Mainland parks and natural areas.

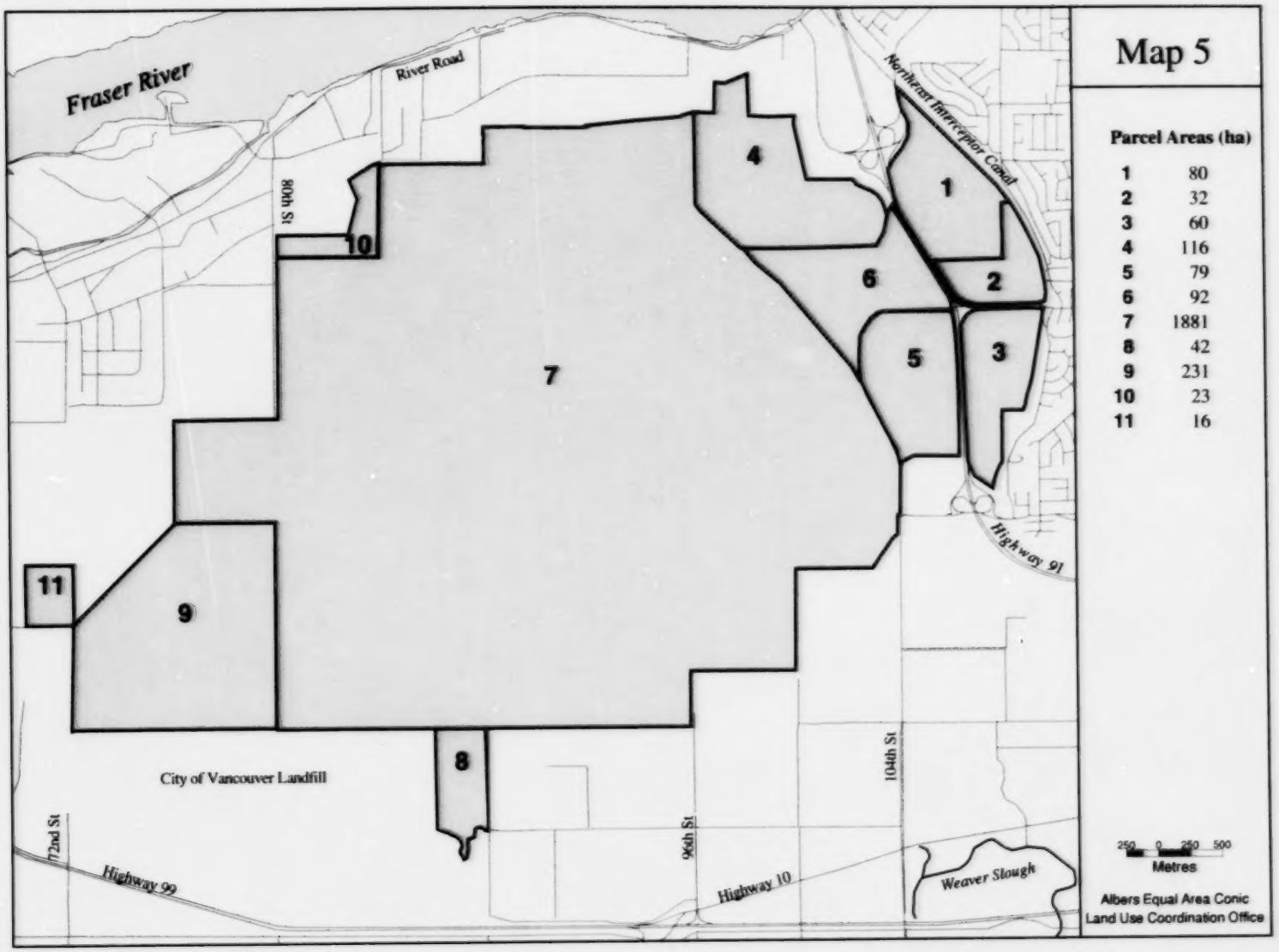
It would be a great tragedy if Burns Bog were to become a protected area, only to see the delicate balance between its plants and animal species destroyed because of contact with humans (and their animals) which increases as the land moves from private to public land status.

It is strongly recommended that consideration be given to setting aside large portions of Burns Bog to be managed not as park, but as a type of ecological reserve, either through signs, permitting systems or otherwise. As a functional counterpoint, such a goal will be more easily accomplished if certain areas are set aside to be managed for public access.

Such a program should be designed in consultation with the GVRD and local municipalities. It may be appropriate to consider the harnessing of the dedication and energy of local, volunteer guardian organizations such as the Burns Bog Conservation Society. The Burns Bog Conservation Society has contemplated fundraising for an Interpretive Centre, which might be placed in or adjacent to the Bog to guide ecologically-sensitive tours.

It is recommended that very careful consideration be given to human and animal impacts should any rezoning for residential purposes be proposed for the portions west of Highway 91.

It is recommended that a process be established, once public acquisition of the Bog has been achieved, to design a Public Access and Management Plan for Burns Bog that is ecologically appropriate.



Map 5. Property parcels discussed in this report

First Nations communities will also have significant interest in maintaining their traditional uses within Burns Bog. If the land is to be managed as ecological reserve, the First Nations in the area should be consulted. It may be appropriate to consider some small financial assistance to enable a Traditional Use Study in the area.

Drainage

The Ecosystem Review Report identifies some potentially serious hydrological impacts from the existing large drainage ditches. If the Delta Fraser Properties lands are to be acquired and managed as protected areas, it will be necessary to address these drainage issues immediately.

Of particular concern is the large recently-constructed drainage ditch along the 80th Street extension, and most other ditches extending into the centre of the water mound (see Figure 4.11 in the EAO Report). Drainage ditches have impacts on the water balance equation as a whole, and also localized impacts extending for 100–200 m on either side of the ditch. (See Sections 6.3, 7.6 EAO Report.) The newly developed ditch system east of the 80th Street extension must be plugged immediately. North flowing ditches in the northeast sector of the Bog should also be blocked. All ditches that extend into the Bog must be considered as candidates for blocking.

In most cases, it may not be simply blocking the end of the ditch. It may require intermittent blockages of varying height. Governments should give immediate consideration, once it acquires the Bog, to establishing a Drainage Plan. Such a plan need not be complicated or expensive, but should take into account the co-ordinated overall impact. It may be appropriate to consult further with Dr. Hebda on these matters.

Agricultural Concerns

Drainage adjustments must be handled carefully to avoid adverse impacts on the agricultural community around the Bog. Delta farmers have expressed concern over possible adjustments to drainage regimes in the Bog of two kinds:

- Farmers (primarily along the southern boundary) concerned that an increase in water levels in the Bog or interference with drainage ditches could lead to flooding of their fields;
- Others, notably cranberry farmers (on the western edge) who obtain some water from Bog drainage ditches for their cranberry operations concerned that plugging the ditches will remove their water at critical times.

A closer analysis of the issues surrounding drainage and the Bog's ecological needs should indicate that there is no necessary conflict with agricultural interests. The solution to both problems is consistent with the Bog's ecological needs: the objective is to keep the water in the Bog, as much as possible, for as long as possible, up to the point of saturation. A natural, healthy Bog, once saturated, does drain water to the outside, but in no greater or lesser quantities than are currently drained. The ditches on the outside of the Bog can continue to serve a 'lagg' function, and properly designed, can continue to drain farmers' fields. The primary problem is with ditches inside the Bog. Further, excess water should be draining from the Bog at the times of year necessary to meet cranberry farmers' needs.

Both of these issues should be addressed in the context of the proposed Drainage Plan.

The Lagg Zone

A longer-term management plan for Burns Bog will also require attention to the lagg zone at the Bog margins, most particularly on the western side, the southern edge, and the area abutting the Vancouver Landfill. Given that the centre of the dome of the Bog is towards the south-westerly portion, the water mound abuts very closely against the boundaries of the Vancouver Landfill, and the agricultural land to the south and west, and will require some attention to design a lagg system that mimics the natural lagg.

The Ecosystem Review Report proposes buffer zones along the northern boundary and the boundary of the Vancouver Landfill. The map of the proposed protected area includes those buffer zones. Some attention should be given to their management.

Environmental Contamination

There are two areas of environmental contamination within the proposed protected area that will require some attention. The southern extension of the 80th Street hog-fuel road has begun to contaminate a growing area of adjacent vegetation, and should be considered for removal or rehabilitation.

The Alpha landfill site, in the northwest corner of the Bog, is an area where the landfill has trespassed onto the Bog. There is reportedly some contamination in that landfill, and this landfill portion may need work to be put to bed.

Connectivity

The Ecosystem Review Report recommends, for wildlife and biodiversity purposes that efforts be made to maintain and re-establish connectivity corridors with the Fraser River, and with Boundary Bay. Any re-development proposal for River Road should consider the opportunity to establish a natural area extending from the Bog to the Fraser River. On a long-term basis, it may be advisable to consider whether a hydrological connection can be established. In respect of Boundary Bay, there is an existing planning process on-going with Ministry of Environment, Lands and Parks, the Canadian Wildlife Service and the Corporation of Delta which is endeavoring to establish a larger plan for these issues, which should be encouraged. Further, in respect of birds and mammal populations in the Bog, many depend on the agricultural lands south and west of the Bog. Protection of Burns Bog alone will not guarantee the survival of these species without protection of those areas for agriculture or other non-intensive uses in the future.

Monitoring

The Ecosystem Review Report recommends a program of monitoring key indicators of ecological integrity. This will be particularly important during the initial few years following the blocking of drainage ditches to determine the effectiveness of that program, and to verify that it has achieved the proper water balance solution. In my view, such a program need not be costly; it could perhaps be organized in conjunction with a university research program on a volunteer basis.

PART 8. RECOMMENDATIONS

1. Burns Bog should be protected. A minimum area of 5920 acres (2400 ha) [as shown on Map 1] is required for ecological sustainability and should be established as public protected lands. This area would include at least 5000 acres of lands now held privately by DFP, and 920 acres currently in public ownership.

2. All levels of government need to contribute to this solution. The province should offer to work in concert with Delta, the Government of Canada, and GVRD for a joint agreement for the resources necessary to protect these private lands, and for the joint establishment of a Burns Bog Negotiating Group to deal with the landowners.

3. Governments should attempt to protect as much of the private Delta Fraser Properties as possible, and all of it if reasonable. The minimum parcels protected or acquired should be the critical lands shown as Parcels 2, 6 and 7 on Map 5, amounting to approximately 5000 acres in total.

4. The remaining areas of DFP lands outside of these areas, and some other public lands inside the study area are not found to be critical to the sustainability of the Bog ecosystem. However, they contain strong ecological values, and if the landowners were willing, should be preserved for regional values, and to help protect the remaining areas. These areas, if acquired, could be considered for an Interpretive Center, or more intensive public access to green space and wilderness values. If desired by the municipality, these areas and the lands owned by Vancouver (for transfer to Delta) could be considered for use under existing zoning or rezoning as considered appropriate, with consideration given in that process to suitable studies and to ensuring no adverse impacts on the protected lands.

5. The Corporation of Delta and City of Vancouver should be approached to contribute their lands, as included in the critical area (marked 8, 9, 10 and 11 on Map 5).

6. The lands acquired in public hands within the Map 1 critical lands should be protected largely as an ecologically sensitive area, managed by the GVRD (with the land to be transferred or leased to the GVRD). Public access within the central parts of the bog and other designated areas should be limited to protect sensitive species.

7. If the lands can be acquired in public hands, a public process should be established to determine an appropriate management strategy for the protected areas. In this process, there should be consultation with local First Nations to determine the cultural inherited values and their desired access.

8 A Drainage Plan should be prepared and implemented immediately.

9 The manager of the lands (GVRD), or other governmental authority should establish a Monitoring Plan, as described in the Ecosystem Review report, to determine the on-going health and viability of the Bog.

10. If voluntary protection cannot be achieved, then government should consider whether a regulatory approach to protection of the key ecosystem processes is appropriate.

PART 9. THE WAY AHEAD

Although society has an important decision before it – how to acquire the private land necessary to protect Burns Bog – a provincial decision alone is not enough. Other levels of government – the Government of Canada, Delta and the GVRD – must also decide the fate of Burns Bog. The other potential partners must have a common recognition of the importance of Burns Bog, and have a common approach to dealing with the landowners.

I have therefore recommended that the Province join with the other levels of government in forming a joint negotiating team to reach a common solution that all can support. I recommend that any further discussions with the landowners take place in coordination with the Corporation of Delta, the Government of Canada and GVRD, and that if British Columbia wishes to move forward on Bog protection at this time, it must immediately invite those governments to be part of the discussions.

A solution, however, also requires that the landowners be willing to cooperate.

I have recommended protection of at least the critical 5004 acres of DFP lands identified by the Ecosystem Review Report. Acquisition or partial protection of any lesser portion would raise serious questions around the long-term viability of the portions acquired. It is therefore essential that the landowner be willing to sell, donate or otherwise give up the whole of this recommended portion. I have also suggested that whatever additional portions can be protected, should be if at all possible.

I have only considered acquisition on a willing seller-willing buyer basis. The landowner in such a situation deserves a fair and reasonable price for the land. Government, on the other hand, cannot justify the payment of an exorbitant price as a responsible steward of public funds. A fair price keeps in mind the location of the lands in a major metropolitan area, but also considers its current zoning, and the significant ecological constraints that come with ownership of a sensitive piece of land such as this.

I have not recommended expropriation. There are a number of reasons for this. There is some doubt about whether the existing statutory regime appropriately allows for the expropriation of this parcel. There is significant public resistance to the concept of involuntary expropriation of private property for ecological preserves, even from some who support protection of the Bog. The most significant downside to expropriation, however, is its great uncertainty as to price. In respect of this parcel of land, valuation is subject to a very wide range of opinion, and small variations in price per acre can have major results multiplied over 5000 acres. For governments, expropriation has the significant disadvantage that acquisition takes place first, and then the price tag comes later. For this much land, that uncertainty can produce a very nasty surprise should an expropriation tribunal take an optimistic view of value, and accordingly may not be viewed as prudent. Equally, from the owner's perspective, if a tribunal takes a pessimistic view, the owner is not only deprived of the property but of the opportunity to obtain a marketplace price.

Valuation for this particular parcel is extraordinarily and unusually complex, and to a great extent, completely arbitrary. Appraisals can be found which range from $30 million to $440 million, dependent primarily on assumptions about the viability of certain uses. Even limited to the existing zoning, quantification of value is subject to significant argument.

Some members of the public might believe that foreclosure on the existing $25 million provincial loan could achieve protection of the lands. It is true that the existing loan has been in arrears in certain aspects, and government may ultimately have to resort to foreclosure

to resolve those issues. However, I must make my view clear that foreclosure alone is not an appropriate strategy or a satisfactory public policy option for those who favor protection of Burns Bog. Foreclosures of this magnitude, particularly where equity may exist above the mortgage price, often take a great deal of time to resolve in court. (Note that the previous mortgagor, Zurich Insurance, had been in foreclosure proceedings on this land for five years without success). Perhaps more to the point, it is extremely rare, on any foreclosure, that the lender ultimately acquires title through an Order Absolute; it is far more common that the land is either refinanced or sold to a third party, and the mortgage paid out. Foreclosure, in other words, is likely to return the Province's money, but will not provide protection for Burns Bog.

Fortunately, preliminary discussions to date have indicated that the landowner may be willing to make available sufficient land to enable these recommendations to be met. It remains a matter for negotiation to determine whether the price requested will be reasonable from the perspective of the negotiating governments.

On the other hand, to date the landowner does not appear to be favourable to a total sale of all of the lands, at any reasonable price. Many members of the public have urged upon us that government should only act if it can purchase ***all*** of Delta Fraser Properties lands – both the critical 5004 acres and the remaining 537 acres. This conflict may be difficult to reconcile, but it is essential that the opportunity to protect the critical portions of the Bog not be lost now.

The provincial government, in concert with Delta and its other potential government partners, should therefore establish a process which ensures that public wishes can be heard, and to determine whether the acquisition of the critical acres meets public objectives at this time, or alternatively whether any purchase should be delayed until the landowners are prepared to sell the whole parcel.

The public needs an opportunity to provide comments as well on this report and the Ecosystem Review Report. The community of Delta, the environmental groups that have fought so hard for Burns Bog, the many people who wrote thoughtful letters and comments, the general public in the Lower Mainland who have spoken out so clearly around Burns Bog — all deserve a chance to read and consider the Ecosystem Review Report and the recommendations contained in this report and to make their views on them known to all governments. The public has been closely involved in all earlier aspects – the Terms of Reference, the design of the study, the selection of consultants, the review of field data, the technical review sessions with the international scientists. These final reports however, have not gone out for public review or as drafts. It would be appropriate to consult the public one more time for final comment on these recommendations.

The public must be informed, however, that one problem with advising government to wait until the landowner will sell all — other than the real long-term possibility that portions of the Bog may ultimately be developed, mined or otherwise used in an ecologically destructive manner in the meantime — is that the fragile water balance and existing drainage problems within the Bog ensures that any lengthy delay will severely threaten the health of the Bog. Accordingly, it would be my recommendation to the public that they urge all governments to move quickly to cooperate in a plan which would protect ***as much of the Bog as can be obtained now,*** providing that at least the minimum critical areas are included.

Greg McDade
March 31, 2000

Appendix 1. Examples from the Extensive Public comment received

"Burns Bog, as a unique domed Bog has the potential for being developed into the greatest eco-tourism destination in the Lower Mainland. Now is the time to grasp this opportunity while there is still enough of Burns Bog left to save."

B. & W. Lehmann
Surrey residents

"I do not know of any other major city that has such a large and (relatively) unspoiled natural area so close (Kings Park in Perth, Western Australia, is good, but a different kind of ecosystem). If we fail to save the Bog, we will have thrown away a unique treasure, and we and future generations will bitterly regret the loss."

B. Kendrick, PhD.
Sidney, BC

"This is an ecosystem unparalleled in diversity of plant and animal life within the Greater Vancouver Regional District. All of what currently remains intact of Burns Bog, be it on private land or Crown land, must never under any circumstances be disturbed or altered in any way or for any reason....Burns Bog is a beautiful oasis of natural balance, and the ecosystem intact has it has been for thousands of years..."

K. Baker
Coquitlam, BC

"It is my belief that it is highly inappropriate to consider the Burns Bog site for any residential or commercial development because of the Boggy nature of the site from an engineering perspective....Environmental concerns aside, this represents not just a loss of ecosystem values, it is a foolish business investment...to subsidize the high costs of developing this site."

P. Hundal
West Vancouver, BC

"...this unique feature of nature has a special significance to future generations. Urban growth continues to blanket the Lower Mainland, making the few wild places increasingly precious."

J. Von Kaldenberg
Richmond, BC

"The Burns Bog is truly one of nature's rare wonders. The provincial ecosystem review is an obvious piece of fluff designed to minimize the enormous value of the Bog. While I am not generally opposed to encroaching on nature for the sake of human population, I do find the Bog destruction to be completely at odds with several human needs such as having clean air, erosion protection from heavy rain, greenhouse gas absorption, clean water, habitat for local and migratory wildlife, and much more."

K. Akhavan
Vancouver, BC

"We must recognize the protection of Burns Bog as a local and global issue, and thus, respond as responsible citizens of Canada and the world with due respect. This concern comes from many of my friends, family, neighbours, and colleagues...."

L. Goncalves and Family
Vancouver, BC

"Less than .000001% of Bogs are raised peat Bogs like the rare jewel we have in our own backyard. It is vibrant with wildflowers and wildlife. A buffer against global warming and estuarine pollution, a producer of oxygen and an air purifier. Growing more than 5000 years, its peat contains a detailed record of our past and must be saved for our children and grandchildren. Burns Bog is the largest piece of environmental "software" on the West Coast of North America."

D. Allan

"For a Bog to survive, it has to be of considerable size – which Burns Bog is."

J. Binkert
Save our Parkland Association

"Burns Bog is the lungs of the Lower Mainland. We don't want to see it destroyed."

B. Carlton

"The costs of destroying Burns Bog far outweigh any possible benefits....Surely the increased air pollution, the steady colonization of green space, the general decrease in quality of life, the loss of our natural heritage/environment to future generations who cannot speak out against this, the loss of biodiversity...should all be enough to warrant the immediate protection of the Bog."

L. Emerson
Victoria, BC

"Thank you for reversing the decision to relocate the PNE in Burns Bog. I think that this would have been the final nail in the coffin for the ecological integrity of our beleaguered yet beloved Bog...."

K. Washbrook
New Westminster, BC

"The possible commercialization of Burns Bog is a pain that brings me almost to tears. This beautiful, ecologically integral and so unique land should be preserved in its entirety, for eternity."

Jennifer Kolanik
Vancouver, BC

"This key biodiversesity must be saved for the future of the environment."

M. & S. London
Richmond, BC

"This area is not only a delightful haven and a site of bio diversity in the midst of the city, it is a proven environmental buffer against global warming. Scientists call this the lungs of the Lower Mainland for a very good reason."

Michael Ireland
Vancouver, BC

"If Delta Council, either present or future, is to consider development, they will require cover from the current suspect and frivolous claims regarding the attributes of the Bog. Lungs of the Lower Mainland. Keeps our fish happy. Saves the Fraser. Protects us from Tsunamis. The world's last Bog. And other appealing one liners. Council can't make a rational decision with their elector marching outside the hall chanting such nonsense."

Ed Ries
Delta resident

"I am very concerned with saving Burns Bog, an incredible acreage that we have in the Lower Mainland...We desperately need to preserve these areas that are close to the urban life of the Lower Mainland. Our quality of life is at stake. Please do all you can to preserve Burns Bog for our children and grandchildren."

Melanie Hollands
Langley, BC

"...its unique purposes as a super efficient air purifier and a buffer against global warming..."

M. Boyle
Vancouver, BC

"The case for maintenance of Burns Bog in a pristine forum is very persuasive for ecological and educational reasons."

Dr. E. Kaellis
New Westminster, BC

"There is so much evidence to prove that this fragile Bog contributes significantly to the oxygen you and I need to breath."

S. Habib

"Already we are threatened by pollution and lower oxygen levels. We NEED the Bog, it helps us."

N. Tsangarakis

"I am writing to urge you to prevent the destruction of Burns Bog. Once gone, it will be gone forever...Burns Bog is not ours to destroy."

Alexander Ng

"Burns Bog acts as a sponge, preventing flooding. It filters water that enters the Fraser. It supplies nutrients for fish and filters out harmful toxins that affect the fish. By absorbing huge amounts of carbon dioxide it purifies the air we breathe. Bogs store even more carbon dioxide than do tropical rain forests."

A. Miles
Gibsons, BC

"I can confidently say that both staff and students and Tynehead Elementary School are committed to the preservation of Burns Bog for its importance as habitat, water purification and green space."

D. Topham
White Rock, BC

"That we can enjoy the Bog in its natural state in its natural self is a blessing to residents of the Lower Mainland. I am a trained botanist and can assure that Burns Bog contains a very rare selection of plants, not normally found so far south."

Vanessa Cliff
Vancouver, BC

"The Provincial Government's ecosystem review of Burns Bog does not look at the cost of destroying Burns Bog. Neither does it look at increased air pollution, loss of green space or quality of life."

Donna Bourne
North Vancouver, BC

"Not only is Burns Bog an exceedingly rare type of Bog, it is also the largest of its kind on the West Coast....Since my first Burns Bog day visit, I have recognized the uniqueness and the necessity of keeping Burns Bog as it is. Our health is directly linked with the health of Burns Bog..."

D. Sesula
White Rock, BC

" My name is Julian. I am five years old. I am writing to save Burns Bog because the animals won't get extinct."

Surrey school child

"I am writing to save Burns Bog. I want to save the animals, nature, clean water and the park. I would like you to build somewhere else."

Seven year old Surrey school child

"Burns Bog is clearly a treasure in a most practical way – as you know the earth is in a critical state and you have the support of thousands as you tackle the problems and decisions.

Lee Mair
England